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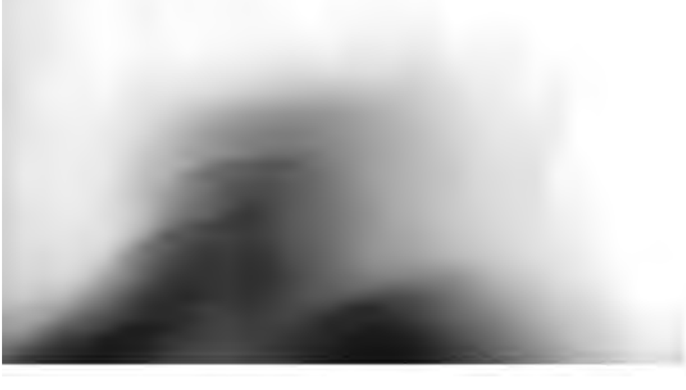

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EDITED BY

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By Prof. Archer, F.R.S.E., Director of Edinburgh Museum of Science and Art.

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By the late Samuel Davenport (Society of Arts).

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PREFACE.

THE object of this series is to bring into one focus the leading features and present position of the most important industries of the kingdom, so as to enable the general reader to comprehend the enormous development that has taken place within the last twenty or thirty years. It is evident that the great increase in education throughout the country has tended largely to foster a simultaneous interest in technical knowledge, as evinced by the spread of Art and Science Schools, Trade Museums, International Exhibitions, &c.; and this fact is borne out by a perusal of the daily papers, in which the prominence given to every improvement in trade or machinery attests the desire of the reading public to know more about these matters. Here, however, the difficulty commences, for the only means of acquiring this information are from handbooks to the various manufactures (which are usually too minute in detail for general instruction), from trade journals and the reports of scientific societies; and to obtain and systematize these scattered details is a labour and a tax upon time and patience which comparatively few persons care to surmount. In these volumes all these facts are gathered together and presented in as readable a form as is compatible with accuracy and a freedom from superficiality; and though they do not lay claim to being a technical guide to each industry, the names of the contributors are a sufficient guarantee that they are a reliable and standard work of reference. Great stress is laid on the progressive developments of the manufactures, and the various applications to them of the collateral arts and sciences; the history of each is truly given, while present processes and recent inventions are succinctly described.

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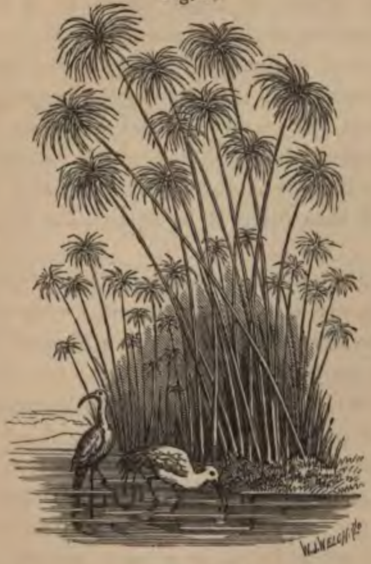
THE MANUFACTURE OF PAPER.

By Prof. Archer, F.R.S.E., Director of Edinburgh Museum of Science and Art.

Amongst the numerous and ingenious inventions of man, it is hardly possible to name one of greater importance than that of making paper, for it has given a facility for transmitting the experience of one generation to all succeeding ones, so that, now the art of printing is brought to perfection, knowledge can be universally diffused and indefinitely preserved. But the art of making paper did not develop itself in its present form until a comparatively late period; previous to which the most civilized nations used a material obtained direct from nature, which with slight preparation served them for writing upon, but not for the thousand other uses to which modern paper is applied. This material, called *papyrus*, whence our name paper is derived, was prepared from certain membranes produced on the submerged portion of the aquatic plant *Papyrus antiquorum* of botanists, and belonging to the Natural Order *Cyperaceæ.* This plant is a native of Ethiopia and Upper Egypt, and also of Syria, and its Syriac name *Babeer* is said to be the root of the Greek παπυρος and Latin papyrus. It flourishes in rivers and marshes in about two feet depth of water, and usually in quiet streams. It was, however, found by Bruce, growing in rapid portions of the river Jordan, where he noticed a curious and interesting fact in its history, namely, that the thick stems, which have somewhat of a pear-shaped section, always present the sharp angular side to the stream, thereby offering the least possible resistance. The immense importance of the paper made from this plant to the ancients was fully appreciated, and consequently we have very full information of its preparation given to us by that indefatigable writer Pliny, while many other ancient authors have also left interesting information upon the subject. The method of preparation, and the varieties of quality made, will be best understood from Fig. 1, which gives a good representation of the growing plant.

It will be seen that it produces numerous stalks, each crowned with a tuft of hair-like spikelets, composing the inflorescence, and a fringe or involucre of hair-like leaves. The stems themselves are about 10 feet high, and often 6 inches in circumference at the base; both the crowning tuft and the stem are of a dark-green colour, and a brown sheath springs from the root-stock, and envelops the latter below and a little above the surface of the water; beneath this sheath, which is coarse and tough, lie several others, which are white or yellowish-white, the innermost ones being very thin and even transparent. It was these membranes which formed the papyrus paper of the ancients, the making of which is thus described by Pliny "Paper is made from the papyrus by splitting it wi a needle into very thin leaves, due care being taken that they be as broad as possible." This must be understood to apply to the membranes of the sheaths enveloping the bases of the stems, and not to the stems themselves. "These membranes are assorted according to their fineness, and made into papers of different quality upon a table, and upon this table the leaves (membranes) of papyrus are laid lengthwise, the jagged edges being cut off at either end, after which a cross layer is placed over them, in the same way, in fact, as hurdles are made. The leaves are then pressed

Fig. 1.



together and dried in the sun; after which they are joined together, the best sheets being taken first and the inferior ones added afterwards. There are never more than twenty of these sheets to a roll." He also asserts that the membranes or leaves adhere, in consequence of a glutinous quality in the water of the Nile used to moisten them during the process. This is now believed to be a mistake, and doubtless some kind of size or paste was employed, which, besides causing complete adhesion of the membranes, also sized the paper, and thus fitted it to receive the ink without running.

Pliny's account of the different qualities of paper is very interesting, and makes us acquainted with its history in the time when the great Roman Natural Historian lived, and probably for ages before; for whether the art began with the Egyptians, or was learned by them from other people, it was not and could not be a progressive one, whilst limited to such a source as the great paper rush. The paper made by the ancients from the papyrus had the qualities of durability and flexibility, probably to a greater extent than our modern manufactures; for it may be doubted whether any papers made by the modern process would have withstood the influence of an Egyptian climate as well as the Egyptian papyri have done; and certainly the collection of incinerated papyri in the Naples Museum, removed from Pompeii, retain more of their original condition than any modern paper would if submitted to the same conditions, for books and paper suffer from the desiccating influence of a dry climate, and become very brittle in time. We are therefore not in possession of sufficient information as to the exact qualities of the ancient paper at the time that it was used, though we are informed that its high price led to its being treated in the same way as vellum was in later times, whilst manuscripts which had served their purpose were submitted to a process which removed the writing, and allowed of their being used again for a similar purpose, like the more recent palimpsests. Papyrus paper continued in vogue in Europe for at least eight centuries after the commencement of the Christian era, after which cotton was employed. About A.D. 800, however, we find Theophilus Presbyter writing of cotton paper as a substitute for parchment in the process of gold beating, and it was most probably a Greek invention, as he says it was called "Greek parchment." At a later period, in the tenth century, paper for writing upon was in use in Greece and Sicily, under the names of "Charta Bombycina" and "Charta Cuttuuea." How this was actually made we know not, except that it was formed of the full-length fibres of cotton, crossing and interlocking each other in all directions like felt; but as cotton is not a material capable of felting, it must have been treated in some manner unknown to modern science—possibly the fibres were diffused thinly through water, and then brought up to the surface in the same way as now done in making paper by hand. Be that as it may, it is certain that cotton paper continued in fashion for a considerable time, and in the end quite superseded the use of papyrus paper. The next great, and indeed the greatest, improvement of all, was the making it from a pulp produced by disintegrating in water some vegetable fibres or tissues. This process does not appear to have been known in Europe earlier than the thirteenth century, and it is not recorded what person or even what nation introduced it. But it is well known, that it was practised by the Chinese and Japanese at a much earlier period. From the very interesting report of Consul Lowder, to Sir Harry Parkes, dated from Kanagawa, July 2, 1870, we learn the following facts: "The manufacture of paper from the paper mulberry (*Broussonetia papyrifera*) was introduced into Japan about A.D. 610. Up to the year A.D. 280, silk, with a facing of linen, was used for writing upon, and thin wood-shavings were also employed. In that year, however, paper was imported from the Corea, and this appears to have been the only paper known to the Japanese until the year 610 A.D., when two priests named Donchô and Hôjô were sent over to Japan by the king of the Corea. Donchô is said to have been a clever man, learned in the Chinese classics, and moreover a skilful artist. Beside the manufacture of paper, he also introduced that of writing ink and millstones into the country.

"Shôtoku Taishi, a son of the reigning Mikado, learned of Donchô how to make paper. But although the paper made by Donchô was very good, it would no
take the ink well; it would not bear rough handlin
and tore very easily; and moreover it was liab
because of its material, to become worm-eaten, see
which Taishi introduced the manufacture of paper o

the paper mulberry; he made four kinds, called unshi, shiku-inshi, haku-jushi, and zoku-hakushi, and he caused the paper mulberry to be extensively planted all over the country, and the mode of paper manufacture to be largely promulgated among the people."

As the method of making paper from the inner bark of the paper mulberry is practically the same in all the countries where it is used, I shall still draw from the above-mentioned report, which is a model for all consular reports, and I wish that I could also transfer its comic illustrations to my pages, as given by the native artist employed by the consul.

The *Broussonetia* or paper mulberry is propagated by root cuttings, a comparatively modern discovery of our gardeners, and is thus described: "In the Island of Kiusin the makôdzu is planted in the ninth and tenth moons, but in Kioto and its vicinity in the first moon, the time varying according to the climate of the place. Some old roots are separated and cut down to a length of about three inches; these are planted so that a little less than half an inch appears above ground. They will grow about a foot high in the first year, and in the second will rise to a height of 2 or 3 feet; in the third year they will reach a little over 4 feet; in the fourth year they attain to 6, or if particularly fine to even 9 and 12 feet. Each year in the tenth moon they are cut down to the roots, and from each stalk fine branches appear the next year, so that in five years a large and dense shrub is developed; the cuttings of the fifth year's growth are used for making paper." This precise account of the growth of the plant is followed by equally clear information as to soil, manure, &c., so that the report may be of great use some day, when we have to look to our colonies for a supply of paper-making materials.

Besides the paper mulberry, the Japanese use the bark of other plants, one of which they call "Ts'kuri-käke," but only for making a choice kind, as it is not to be had in abundance. Others more abundant are the "Kajiso" and the "Takaso," all deciduous trees.

The processes employed by the Japanese in the manufacture of paper are numerous; first, the twigs are cut into lengths of two to three feet, and are steamed until the bark is easily stripped off, quickly dried, and tied up into bundles of rather more than a quarter of a hundredweight. They are next washed in a stream of running water for from twelve to twenty-four hours, after which the outer bark is carefully scraped off with a knife, and is reserved for making inferior kinds of paper. The cleaned inner bark is then again submitted to the action of running water and thoroughly washed, then steeped in buckets of water for a time, and after having the cold water expressed, is boiled until all the glutinous qualities are removed, producing a mass of fibre called "sororo." This is again boiled and stirred in water, to which some ashes of buckwheat husks have been added, probably in consequence of the caustic alkali, which help the disintegration of the fibre. The sororo is the put into a basket, and placed in running water, i order that the insoluble portion of the ashes may removed. The sororo is what our paper makers wou call half-stuff, and requires the addition of a sizing material, which is obtained from large fleshy roots of a malvaceous plant called "tororo." These roots are cleaned, skinned, beaten, and afterwards boiled in water, which becomes glutinous, and is mixed in due proportions with the sororo, so as to produce a pulp of proper consistency, which is afterwards worked in pretty nearly the same way as the hand-made papers of Europe. Japan is *par excellence* the country of paper making, which is carried on in twenty-nine districts, producing two hundred and sixty-two varieties. Many are intended for special uses, such as for writing songs and verses upon, dressing dolls, wrapping up presents, making fans, umbrellas, artificial flowers, and candle wicks; for handkerchiefs, papering screens, tobacco pouches, and lanterns; for waterproof clothing; for straining oil, tying the hair, and decorating ladies' hair; for making string, and all the uses to which paper is put in European countries. A complete history of the varieties of Chinese and Japanese papers would form an extensive and interesting volume, for both these nations, but more especially the latter, have a versatility of genius for the application of the material which is truly astonishing. The above list only conveys a faint idea of their cleverness in this respect; moreover, the sketches given of the processes show that its production is so laborious, that we cannot help wondering that its application is so universal. It is only now in Europe that a clever firm is making imitation leather for bookbinding of paper—an old fashion with the Japanese.

The latter make a sort of netted fabric of paper for underclothing in hot weather; string, which will wash; hats and helmets, which will turn a sword; the tube of a Japanese telescope is of paper, as are also their hair-pins and hair-strings; while the screens, which form a large part of their houses, are covered with it. In fact it is, apart from food and clothing, the chief necessary of Japanese life.

At what period the Chinese learnt the art of paper making we know not, but it is most probable that the Coreans who taught the Japanese learned it from the Chinese, and it is certain that no people have ever surpassed them in producing paper from such materials as the bark of various trees, especially that of the paper mulberry and the stems of bamboo; and they are only excelled by the Japanese in the extensive use which they make of it.

Of the early history of the art in India, we have little reliable information.

The leaves of several palm trees were long used for writing upon by means of a sharp iron point, and in Burmah and some other parts continue to be so to this day; but hand-made paper from pulped materials has long been in use, though whether the knowledge was received from China or from Europe there is no clear information. At present the materials used by the native paper makers are the leaves of the screw-pine (*Pandanus odoratissimus*), the fibre of the plantain jute in the form of old gunny bags, the sun hemp (*Crotalaria juncea*), the barks of *Daphne cannabina* and *Hibiscus cannabinus*, with some others which are only occasionally used.

The greatest advance in the manufacture was the substitution of linen rags for cotton, but whether this originated in Europe or not is a moot point. Mr. James Yates, in his able work 'Textrinum Antiquorum,' claims the invention for the Egyptians of the twelfth century, and in support of his proposition he quotes from the writings of Abdollatiph, an Arabian physician who visited Egypt in 1200, "that the cloth found in the catacombs, and used to envelop the mummies, was made into garments, or sold to the scribes to make paper for the shopkeepers." Thus, as the mummy cloth was linen, he concludes the evidence to be sufficient, that paper from linen rags was made at a very early date in Egypt. Other writers insist, that it was an European invention of the middle of the thirteenth and commencement of the fourteenth century. The proof adduced for the earlier date is the existence of a small manuscript on linen paper, which is now in the Imperial Library at Vienna. This MS. is a mandate of Frederick II., Emperor of the Romans, and has reference to a dispute between the Duke of Carinthia and the monks of the Monastery of Gőss in Upper Styria, which from collateral historical evidence is believed to have occurred in the year 1243. The very early use of linen paper by the Arabians and Persians raises another question, whether it is not altogether an Eastern invention introduced by them into Europe, and possibly obtained by them from the Egyptians.

The manufacture of paper from linen rags can be traced far back in the history of Spain, and it is highly *probable that the* Spaniards learned it from the Moors.

Valencia and Catalonia were famous for this manufacture, which was introduced from Spain into France in the latter part of the thirteenth century, and later still about 1312 into Germany. The Germans soon became extensive makers, and one of them named Spielmann brought the invention over to England, and established at Dartford the first paper mill ever erected in this kingdom, an acquisition considered so important and valuable, that he was knighted by Queen Elizabeth.

It must not be imagined that Spielmann's paper mill was like those of the present time. The machinery which he employed, was only for the purpose of reducing the linen rags to pulp, while all the subsequent operations were performed by hand, as is still the case in countries which have not yet adopted the modern inventions. The pulp was formed by beating the rags or other material after boiling and macerating in water, with stampers moved either by water or wind power. The latter is only used in Holland, a great paper-making country, where the hand process is still in vogue in the following manner.

The pulp mixed with sufficient water to give it the appearance of milk and water, is run into a small vat, by the side of which stands the *vat-man* with an implement called a *mould* (Figs. 2, 3) in his hand. This is a flat frame in two divisions, having a sheet of fine wire gauze, level with its surface, as in Fig. 2. The extraordinary skill of the Chinese and Japanese in working bamboo stems into exceedingly fine fibres leads them to form a gauze of that material instead of wire, or else to place the fine threads in parallel lines sufficiently close together to form the surface of the mould. This is also done by European hand workers, who thus produce two varieties of paper, the one made on the gauze being called *wove*, to distinguish it from the other which shows the straight lines on its surface, and is technically called *laid*. Before using the mould, the workman places upon it another thin frame corresponding to it in form, but having no gauze or laid wires. This implement is called the *deckle*, and is for the purpose of converting the mould into a shallow tray, capable of holding just sufficient of the pulp to make a thin sheet on the mould when the water has strained through, which it very quickly does. The vatman then places the mould on a stand in an inclined position, and takes another, with which he repeats the operation; another workman, called the *coucher*, takes each mould, after it has rested a few minutes to let the water drain off effectively, and turns the sheet of pulp on its surface to a small board covered with felt or flannel, called the *couch*. A slight pressure makes the sheet of pulp leave the surface of the mould. The sheet is transferred from the couch to a sheet of felt,

Fig. 2.

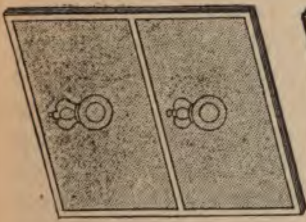


Fig. 3.

and upon this the operator places ultimately a series of sheets of soft paper and of felt, until the pile consists of from four to eight quires of paper, and the intervening sheets of felt. This pile, called a *post*, is put into a powerful press, which presses out the moisture, and leaves the sheets of paper sufficiently dry and strong to be separated from the felt. Sometimes the sheets of paper are again piled one upon another, and re-pressed without the felts; then the sheets are hung separately on lines of horsehair ropes in a drying room until quite dry, the paper in this state being unfit for writing upon, and in fact bibulous or blotting paper. This condition is removed by dipping them separately into a weak warm solution of *size*, which must be very pure, if for fine white paper. It is again dried with great care, and not too quickly, for if too much heat is applied, it acts on the size, and gives a yellow tinge to the paper. The sheets are next calendered by passing them through hot steel rolls, or *hot pressing*, and folded and arranged into half quires, and the edges trimmed; formerly they were also gilt, or blackened, if for mourning. It will be seen that the hand-making of paper is a tedious process, and not at all adapted to meet the immense demands of the present day; and the change was felt to be necessary at the beginning of the present century, when a Frenchman named Louis Robert tried to perfect a machine for making paper, though he was not completely successful. Bramah, too, in our own country, went so far as to take out a patent for an invention of his own in 1805, but he failed likewise. The invention of

Louis Robert was brought to England by M. Didot, but was not adopted, until in 1806 M. Fourdrinier made great improvements in it, and paved the way for the numerous additions, which have made the paper-making machine of the present day one of the most beautiful and perfect pieces of mechanism ever used by man.

Aided by such mechanical power, the production of paper is now only limited by the supply of the material, and the demand for a suitable substance is enormous. At present linen and cotton rags, esparto, and wheat straw, are the chief materials used in this country for writing and printing paper, but for the commoner kinds of packing and wrapping papers a variety of materials are used. The processes of converting them will now be briefly described, commencing with RAGS. It is not customary to use linen and cotton together, therefore the first process is the sorting and picking out of seams, buttons, and any foreign matters which would interfere with the subsequent operations, a work which is usually done by women and girls, and requires considerable care. The operators stand at small tables, in what is technically called the "rag-house," and in the middle of each table is fixed a sharp scythe-shaped knife, above an opening in the table top, with a wire grating for letting through dirt, pins, buttons, and other matters, which fall into a drawer placed to receive such refuse. All sewn pieces are torn open and examined, and, by means of the fixed knife, cut into small pieces two or three inches square. As it is of much importance that they should be freed as far as possible from dirt, they are next passed through a revolving cylinder of wirework, with meshes sufficiently large to act as a sieve. In the best conducted paper mills the *dusting* is often done before the sorting and cutting, out of regard chiefly to the health and comfort of those employed.

After these operations, the cut rags are transferred to the boiler, which, in the most improved mills, is a huge spherical-shaped vessel, suspended like a globe by two projecting axes that rest on strong iron pillars in properly formed *journals.* The axes are hollow, and through one of them steam is communicated, which escapes by the other; and a number of projecting iron rods are so arranged in the interior, as to keep the rags from gathering into one mass when the machine is revolving, which it does by steam power. The rags are introduced through a large hole fitted with a lid, made steam-tight by means of a levered screw. When charged with rags and some water, the boiler, which is usually from 6 to 10 feet in diameter, is caused to revolve very slowly, at about two revolutions per minute. This iron boiler is disliked in mills where paper of the finest quality for writing on is made, as some particles of iron removed from the interior by friction are apt to get mixed in with the rags and produce iron-mould. Steam-tight wooden vats with mechanical wooden stirrers are preferred; hot water containing caustic soda being used with the steam to wash the rags.

When taken out of the boiler, the rags are immediately drained before they get cold, and are afterwards transferred to the *washing and beating* engine; the construction of which cannot be understood without the following figures. Fig. 4 represents one in outline, and Fig. 5, in section.

Fig. 4.

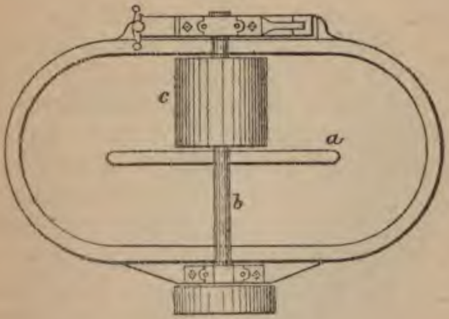


Fig. 5.

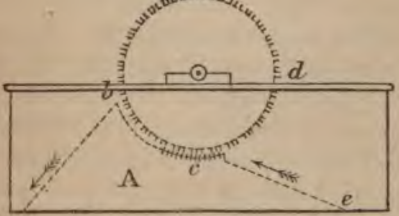
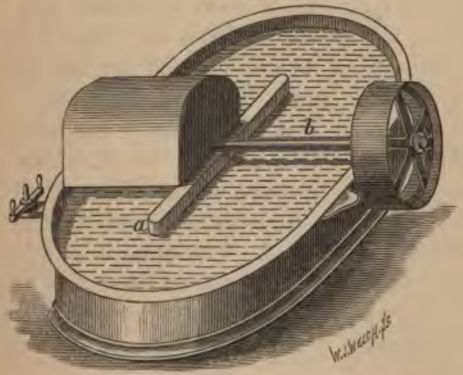


Fig. 6.

Formerly the vat of the engine was made of wood, lined with *lead or* copper, the shape being (Fig. 4) an ellipse with slightly flattened sides; now, however, they are cast in iron, all in one piece, and usually of the following dimensions, length 10 feet, width 4½ feet, depth 2½ feet, though they are often made much larger. The bottom is not level, but has upon it a solid elevation, theoretically represented in Fig. 5, A, which is technically called the *mid-feather*, and is a most essential part of the arrangement. The partition (Fig. 4, *a*), which is placed in the centre of the engine, and is sometimes made as in Fig. 6, divides the interior, so that there is an exactly equal space all round. It also helps to support a shaft (Fig. 4, *b*) connected with the driving power, and worked by it; this shaft bears upon it the cylinder called the *roll*, Fig. 4, *c* (seen in section in Fig. 5), on which is set a series of parallel sharp ridges called the *knives;* while on the mid-feather (Fig. 5, A), at the point marked *c*, is placed another set of knives, which nearly touch those on the roll which revolves from *d* to *b* (Fig. 5). The roll itself is usually of wood, such as elm, about 24 inches in diameter. When in action, it revolves from *d* to *b* (Fig. 5); consequently if the shell be filled with water, and the roll revolves, a current must be formed from *e* to A (Fig. 5); if, however, instead of mere water, a mixture of rags and water is operated upon, the rags are dragged in between the knife edges on the roll and those on the mid-feather, and are gradually reduced almost to pulp, a state technically called *half-stuff*. The engine is seen in operation in Fig. 7. An essential part of the washing and beating is a constant flow of clean water into the engine, and a filtering or straining of the overflow to prevent loss of the material. The simplest method for supplying the water is by a 6-inch pipe bent over the edge of the engine, the outflow being through a hole covered with a fine wire-gauze strainer, or a piece of flannel.

Fig. 7.



The general arrangement, however, in the best constructed mills, is to pass the fresh water into small cisterns raised about 3 feet above the level of the engine vat. In this cistern there is an apparatus of a cylindrical form, for the purpose of stopping sand or any other impurities as the water passes through it; it is of wire gauze, and from its interior the water passes by the outlet pipe into the engine, from which it is removed as fast, by an ingenious contrivance in the form of a drum made to revolve in the opposite half of the engine to that occupied by the beater and mid-feather. This drum consists of wood at its two ends, and wire gauze on its periphery; internally it has a number of partitions, usually four, from its axis to the circumference; and there is an opening in the wooden end, nearest the middle of the engine in its centre. When this apparatus is made to revolve, and is immersed in the stream of water and rags, it lets the water through to its interior, and the rags are held back by the wire gauze. The revolving motion rapidly pumps the water that flows through the hole in the end of the drum into a movable trough, which carries it away at exactly the same rate as it is received in the engine vat from the fresh-water pipe, so that the level is constantly maintained. The drum is so fitted, that it can be raised out of the vat, or lowered as required. When mere washing is required, it is brought into use, but its operation is suspended when the bleaching is going on.

The amount of rags operated upon at one time is usually between 300 and 400 lb., although engines have been constructed to carry much larger quantities. The roll, or what may be called the grinding wheel, is capable of being removed nearer to, or farther from, the bars of the mid-feather, so as to allow room for the rags when first put in to pass between; and as they are broken down, it can be brought nearer until the rags are sufficiently reduced for bleaching. The flow of fresh water, and its removal by the drum, are then stopped, and a solution of chloride of lime (*bleaching powder*) is pumped in, and the engine kept going, until the broken-down stuff is sufficiently bleached. It is next drawn off into another engine at a lower level called the *poacher*, which is usually of sufficiently large size to receive the contents of several *breakers*, as the first set of washing and beating engines are technically called. The poacher has no grinding tackle, its operation being merely to keep up a rapid current in the half-stuff and the fresh water with which it is supplied, in order to wash out as much as possible the bleaching material. The poaching machine having done its work, its contents are passed down into the draining vats, which are made of wood with perforated bottoms, through which the water drains away until the half-stuff is left damp, and as compact as the crumb of a loaf of bread. In some works, the process of bleaching is carried on in a long chamber of a width sufficient to hold two rows of bleaching chests, with a 4-feet passage between them; they are of uniform size, and the number is regulated by the extent of the operations of the mill. The chests are square, and formed of thin slabs of stone, with a perforated false bottom, whilst in the real bottom a valve is so arranged, that all the liquid which drains through can be passed into a reservoir and pumped up for use again. The quantity of stuff placed in each bleaching chest is usually a hundredweight, and the time required for bleaching is twenty-four hours. The bleaching solution consists of a mixture of chloride of lime and water, the quantity for each chest being about 12 gallons of water and 6 lb. to 10 lb. of the bleaching powder, according to its strength, and to this is generally added a few gallons more of the partly spent liquor of previous operations, collected as before mentioned in the reservoir below.

Frequent stirring is necessary, to ensure an uniform action of the bleaching material all through the contents of the vat. The bleached stuff is allowed to drain out by opening the valves in the bottoms of the chests, and, when sufficiently drained, it is taken out, and generally pressed in boxes to remove as much as possible of the bleaching fluid before the next operation, which is conducted in an engine like that previously described as the washing engine. In this, which is usually called the intermediate engine, the grinding tackle on the mid-feather and roll is blunt but carefully adjusted, so as to act upon the half-stuff, and rub it down still softer and finer, whilst the water in the engine is effectually removing every trace of the chlorine, which would otherwise prove very injurious. The intermediate washer is so placed that when it has done its work, the pulp can be let out by a valve in the bottom into the thud or beating engine, in which the grinding tackle is set sharp and fine, so as still further to reduce the fibre of the stuff, which is accomplished after several hours' beating. It is now in the condition of finished pulp, ready for being converted into paper, for which purpose it is allowed to flow out of the engine by a valve into the *pulp vat*, which receives the contents of one or more beating engines. In this it is kept slowly stirred by a mechanical arrangement, and is made to flow in regulated quantity to the paper machine, which is placed at a lower level to facilitate the transmission.

The modern paper mill is one of the most beautiful and ingenious of recent contrivances, but although

d, Lith.

hundreds of minor improvements have been made in it to suit it to special circumstances required by the variety of material used, or kind of paper to be made, the actual principles of its construction are the same as when it was first brought to a practical state by Messrs. Fourdrinier and Donkin, who perfected the invention of M. Louis Robert. The addition of the *knotting* machine, patented by Mr. R. Ibotson, was a great improvement in the preparation of the pulp for the machine. Ibotson's invention is thus described in the abstract of patent dated 30th July, 1830:

"Improvement on improvements in the method or apparatus for separating the knots from the paper stuff or pulp used in the manufacture of paper; and these consist in making the bottom of a sieve or strainer of a number of bars, having parallel spaces between every two of the bars which are adjoining to each other, and making the width of each bar to equal or exceed the length of the fibres composing the paper stuff or pulp to be strained; also making the bottom of the said sieve or strainer from one or more sheets of metal, by cutting slits through them, the slits to answer the spaces before described; also applying such sieves or strainers for separating the knots from the stuff or pulp of which the paper is made."

Ibotson's knotting machine has now been brought to such perfection, that the pulp flows to the pulp vat attached to the machine (A, Figs. 8 and 9) with perfect uniformity of substance. The machine, which almost instantaneously transforms the pulp until it looks like skimmed milk, can only be understood by aid of the drawing (Fig. 8), which represents one as seen from above, and Fig. 9 which gives the elevation of a machine. A, as before mentioned, is a small vat which receives the pulp from the knotting machine, in which a small wheel or cog in motion keeps it stirred, and from which it overflows in a stream of breadth equal to the mould or sheet of wire gauze (B B). This forms a continuous band, kept constantly moving around the cylinders (Fig. 9, *a a*), and its upper part, which receives the pulp, maintained at a perfect level by running over the tops of the small brass rolls (Fig. 9, *b*). The pulp is prevented from running off at the sides by a small band of vulcanized indiarubber called the *deckle strap*, which is kept in position on the wire gauze, and at the same time in movement by a series of rollers over which it passes (Fig. 9, *c c c*). As the pulp travels over the mould of wire gauze, the water drains through and is caught and pumped up again into the vat, so as to save any pulp which escapes with it. This drainage is moreover greatly aided by suction troughs (Fig. 9, *d d*), from which the air is exhausted by the pumps (Fig. 8, F), so that by the time it reaches the *couching rolls*, and the wire gauze returns after touching a web of blanket (*e e*) running over a series of moving rolls, the paper leaves the wire and is carried on by the woollen blanket. It receives a gentle pressure as it passes through the couching roll, which removes enough of the moisture to give it a consistency, which is further increased as it passes successively, supported on the blanket, through the first and second *press rolls* and the first set of drying cylinders. When it leaves the blanket and goes unsupported through the press rolls, still slightly damp, these rolls remove all marks left by the wire gauze or by the felt blankets, and pass on the web of paper to the second drying rolls, where the drying is completed. The large cylinders of the drying rolls are hollow, and are filled with steam for producing dryness rapidly. After drying, the paper is passed through a trough of thin size, and, by the most modern improvements, slowly redried by passing over numerous wire cylinders, with fanners inside moving in the opposite direction. These cylinders carry on the web of paper to another pair of steel rollers (the calender), in which it is tightly pressed, and from which it passes smooth and fit for writing or printing upon. Here it is either reeled off in a continuous web, often miles in length (those used for printing by the Walter press are usually four miles), or it passes through the cutting machine (E, Figs. 8 and 9), by which it is cut into sheets ready for hot pressing and folding. The former of these two operations applies only to papers of fine quality, chiefly that used for writing, and consists in placing a pile of alternate sheets of the paper and plates of thin copper or sheets of highly-pressed and calendered millboard, and submitting the pile to great pressure in a hydraulic press. There are other means of pressing the paper whilst still in the web, by machines called *super-calenders*. The webs are, however, narrower than those thrown off from the paper machine, having been passed through cutting machines, which slit each web longitudinally into several smaller ones of the width of the intended sheets of paper. As the slitter receives the web through rollers and the cutting goes on, each strip is received on a reel which, when full, is taken to the super-calender. This machine consists of a series of alternate rolls of polished chilled iron and condensed millboard, screwed down upon each other by regulating screws on the top of the upright posts, which carry their journals one above the other. The web of paper passing through these rolls receives great pressure, which condenses, hardens, and smooths it, after which it is removed to another cutting machine, which cuts it into the proper sized sheets.

On referring to Fig. 8, an arrangement will be seen at G for producing the *water mark*, when required, on paper. For this purpose there is a cylinder of beautifully wrought brass wire with the device woven in, like a pattern in any kind of damask cloth. As the cylinder revolves with the slightest possible pressure upon the slightly hardening pulp, it leaves the impress of the device or paper mark, which none of the subsequent operations will remove. In hand-made papers the mark is woven into the wire, which forms the web of the mould (Fig. 2). The water mark is of great importance in some kinds of paper, and especially in the small hand-made sheets used for bank notes, &c.

So far my description of the processes employed in paper making has referred chiefly to that made from linen and other rags, but within the last twenty-five years a great revolution has taken place in the manufacture of paper, mainly owing to the vastly increased consumption caused by the abolition of the duty. The demand led to numberless experiments on other materials as substitutes for rags, which rapidly became so scarce as to produce what might be called a paper famine. Hundreds of vegetable substances were tried in vain, the great difficulty being to find a fibre which would go through all the operations necessary to form it into paper and ensure a proper commercial profit. Almost every plant that grows on land, and even some aquatic plants, will yield paper materials, but so far we have only discovered one which can fairly compete with rags, and that is esparto, alfa, or diss. The former is its Spanish name, while the two latter are given to different qualities in North Africa, which may prove to be different species, as one varies considerably in appearance and other qualities from the former. The plant is the *Stipa tenacissima* of Linnæus, and the *Macrochloa tenacissima* of Kunth. It grows abundantly in the southern parts of Spain, whence the best quality is obtained, and also in Algiers and Tunis. This remarkable grass, known to the Romans as a material for making ropes, and used from time immemorial by the Spaniards for making mats, baskets, &c., has proved to be the best of all paper-making materials directly derived from the vegetable kingdom. Rags, of course, have undergone some of the processes, such as partial separation of fibres and bleaching, and are therefore best for the paper maker when procurable in sufficient quantities; but of all other substances which have been tried, esparto comes next, and fortunately is found in immense abundance, our imports last year amounting to no less than 150,000 tons. It is imported in bundles or bales, tightly pressed by hydraulic presses, and when received at the paper mills, is carefully picked over by women and girls, who remove all roots, pieces of other kinds of grass, &c., as it is found that none of these mixtures will go through the bleaching process so well, and therefore are certain to produce blemishes in the paper.

The esparto, having been carefully picked, is transferred to the boiler, a huge vessel capable of receiving a very large quantity, to which is added a certain proportion of soda ash or of caustic soda. The alkali dissolves the cellulose which binds together the fibres of the plants, and the stiff hard grass comes out soft and limp, in which state it undergoes another picking by women, who by practice readily detect unsound or bad pieces, and remove them. This being done, the material is ready for the breaking engines (like the washing engines before described), and after being thoroughly washed and broken down in fresh water, is covered with the bleaching liquid until sufficiently white. It is then washed in the poaching engine, drained and pressed, transferred to the beating engines, and reduced to pulp ready for the machine. Nearly all the printing paper now used is made from esparto, and so much improvement has been effected in the paper machines, that it is produced with astonishing rapidity, and comes off from the machine calenders so highly finished, that no further calendering or pressing is needed.

Much paper is manufactured on the Continent, chiefly in Sweden and Belgium, from pine and aspen woods, and efforts have been made to introduce it into this country, so far, however, without much success. Small quantities of half-stuff from these woods are however imported, and are used by some paper makers to mix with other materials. For brown papers, wrapping papers, and other common kinds, where chemical bleaching is not required, such coarse materials as old ropes or junk, straw, and many others are used, besides waste paper, which is available for further use after being pulped; and many of these papers, and not a few of the finer qualities, are charged in the pulp state with large quantities of clay, ochre, and other mineral matters, which, if they do not improve the quality, add greatly to the weight, and consequently to the profits of the paper maker. It is doubtful if this practice is injurious to the usefulness or durability of the paper, when it is confined within moderate limits.

Cardboards, millboards, and other thick paper fabrics are either hand made, or in machines with different modifications to suit the different thicknesses, and some of them are divided into sheets of the required size, and dried in drying chambers, instead of on drying cylinders.

The number of materials which have been tried, or suggested for paper making, is very considerable. This is a list of the principal ones; those marked with an asterisk being more or less in actual use in this or other countries:

*Linen rags, flax, *flax tow, and refuse.
*Cotton rags and cotton wool.
*Old ropes (or junk), *oakum, *hempen canvas, and sacking.
*Old sacking and gunny cloth, made of jute.
*Esparto *grass,* *wood of various kinds,*straw,*maize husks.
**The dwarf palm* (*Chamærops humilis*).

FIBRES PROCURED FROM—

The leaves of the American aloes (*Agave*).
The leaf-stalks of the banana, the plantain, and the *manila or textile banana (*Musa textilis*).
*Bamboo and rattan canes.
Stems of the horse bean, French bean, and scarlet-runner.
*Hopbines, nettles, thistles, mallow stems.
New Zealand flax, sugar-cane refuse, tobacco stalks.
Beetroot, refuse from the sugar works.
Grasses, clover, lupin stalks, sunflower stalks.
Various rushes, the yellow iris, bryony roots.
Twigs of the common broom and heather.
Rhubarb stalks, mustard stems, after threshing.
Pineapple leaves and the sea grass (*Zostera marina*).
The bark of the baobab tree (*Adansonia digitata*).

MISCELLANEOUS SUBSTANCES—VEGETABLE AND ANIMAL.

Peat, moss, the bracken fern.
Sawdust, spent tan, bast matting.
Barks of various trees, especially the *paper mulberry.
Floss silk, wool, fur, leather waste.
Asbestos.

The greediness of patentees has been strangely developed in the matter of paper materials, for some of them have included in their specifications "all the fibrous plants growing within the tropics." It is quite true that every plant which furnishes a fibre, that is, nearly every plant, will yield paper; but it is very remarkable how very few have been found which could be used profitably.

VARIETIES OF PAPER IN USE IN GREAT BRITAIN.

Writing.

Hand made, machine made, tub sized, machine sized, straw, account book (hand made), account book (machine made), ledger, envelope, copying (tissue).

Printing and Drawing.

Newspaper, magazine, book, toned, plate (for engravings), plate (toned veneered), chart and map, lithographic, music, drawing (hand made), drawing (machine made), long elephant, elephant, crayon, coloured printings, bank note, town, cheque.

Wrapping, Packing, &c.

Bag paper. Grocery papers—caps (small, double, and thin), hands (small, double, royal, blue, white, and grey). Browns—thin, glazed and unglazed casings, air dried, machine dried, cutlers, hand made (rope), hand made (whitey-brown), skips, manila, cartridge, middles and Jacquard middles, mill wrappers, sugar blues, sugar purples, hosiery, coloured demy, coloured demy (glazed), pin and needle, starch, bowl.

Boards.

Mill, mill (hopbine), glazed (vat made), loom cards (vat made), engine, pressing, straw, white card and enamelled, pasteboard.

Miscellaneous.

*Blotting, tissue (white and coloured), collar (for imitating linen), enamelled, tracing, *filtering.

* These are unpressed and unsized papers.

Ordinary writing papers are distinguished in the retail trade by the form and size of the sheets, as foolscap, pot, post, and note paper. The three first obtained their names from the water marks with which they were originally impressed, namely, a fool's cap, a tankard, and a postman's horn.

The following trades are wholly dependent upon paper:

Button card manufacturers.
Cardboard box manufacturers.
Card cutters.
Card (playing) manufacturers.
Gold and silver paper makers.

Paper bag makers.
Paper box and case makers.
  „ borderers.
  „ embossers.
  „ glossers.
  „ marblers.
Pillbox makers.
Valentine makers.
Publishers and printers.
Book and card-edge gilders and marblers.
Machine rulers.
Music-paper rulers and printers.
Numerical pagers or printers.
Railway ticket printers.
Pattern book makers.
Vegetable parchment makers.
Papier-mâché makers.
Carton Pierre manufacturers.
Paper-hanging printers or stainers.

Many others are more or less connected with paper, as a principal material for their industry. These, however, and the previous sketch of the manufacturing processes are sufficient to show the immense importance of the material, and how much it has taxed the ingenuity and industry of man. We might look with unalloyed pride, were it not for a drawback which it is sad to have to note, and that is the shameful waste which is in our country everywhere seen. When it is borne in mind that every scrap of paper can be used over again, it is a disgrace to our much-boasted intelligence that there is no organized plan for collecting our waste paper, and reconverting it to useful purposes.

PRINTING AND BOOKBINDING.

By Joseph Hatton.

The present may fairly be called the age of printing. No art has undergone changes so great in so short a time, and no industry has been developed more rapidly. Not more than sixty years ago, the 'Times' was printed by hand, and even some twenty-five years since, I saw a country newspaper printed on a Columbian press at the rate of 200 an hour. A few years earlier the old wooden press, built on the principle of the common clothes-press, was in very general use. The platen was mahogany, and had frequently to be replaned, the surface becoming irregular through constant use, while the iron bed of the press upon which the form was placed, rested upon well-packed sawdust. Now and then it had to be reset with the aid of a spirit level, and in those days, the outside speed of production was what pressmen called "a token," or 250 copies per hour. Then it was something for a man to see his name in print, for even large business firms wrote their invoice headings, and it was a rare thing to see letter paper with printed addresses. Ordinary tradesmen certainly did not aspire to the dignity of printing, wall-posting was in its infancy, and placards were chiefly confined to official announcements, proclamations, sales by auction, and public amusements; and, compared with the gigantic productions of the present day, the posters were unobtrusive and ineffective. Railway stations had not been formed into advertising bureaus; colour printing was a fine art, almost limited to lithography; and the most ambitious of billstickers had not even dreamed of the time when his successors would call themselves advertising agents, and drive their carriages. When Mr. Smith, a newsagent, asked the Directors of the North-Eastern Railway to allow him to sell books at their stations, the idea was regarded as a questionable innovation, and the applicant, though courteously treated, was classed with the book-hawkers, who travelled about the country, and held no better position than the vendors of bootlaces. This same enterprising and far-seeing Mr. Smith, at his death left to his son a monopoly of the most remarkable and lucrative kind. Mr. W. H. Smith can "make or break" a newspaper; his chiefs revise the list of the "popular books" of one or more large publishing firms; while Mr. Smith himself, returned to parliament for the most aristocratic and learned of London constituencies, is also a member of Her Majesty's Government. This is one of the results of progress in printing. It was the steam printing machine that laid the foundation of the fortunes of our great newspaper, advertising, and publishing firms. As for printers themselves, from a commercial point of view, they are rather the victims of enterprise than gainers by progress. After the first great step in mechanical science connected with printing, invention was so rapid, competition so severe, that printers have been called upon to refurnish their establishments over and over again, and there seems to be no end to the new and novel combinations for perfecting the art, and increasing the speed of production. The result has been to the advantage of the public and others outside the printing office. Publishers have thrived; newspaper proprietors have prospered; advertising agents have made fortunes as middlemen, with little or no risks; paper makers have flourished; but the printer *de facto*, the mere producer, with his ingenuity, his new ideas, his expensive machinery, the wages of his workpeople regulated by trades' unions; he has been frequently worsted in the battle. He has contributed to the progress of his art; he has helped on the march of knowledge; he has increased the enlightenment of his age; and has too frequently finished his work in the Bankruptcy Court. Some of the best and most extensive of London printing firms have failed within the last few years, most of them through excessive enterprise and reckless competition.

For many years, the London printer not only held his own immediate field free from outside opponents, but he sent travellers into the provinces for orders. As the centre of the world's enterprise, the market for inventions, the headquarters of new ideas, London had the first benefit of improvements. The country printer did not attempt to compete with town; but railways and telegraphs eventually dethroned this centralisation of an important art and manufacture; and at the present moment an immense amount of printing for London is done in country offices. The "copy" of many of our leading authors goes into the provinces to be set up and printed. Millions of books for the London trade are produced in the provinces. Guildford prints many of our novels. Nottingham has manufactured some of the most successful of those coloured pictures which are issued as supplements to certain of our weekly newspapers. Bradford sends out the showy posters which adorn or make hideous our void houses and hoardings. Edinburgh has long been famous for fine printing, and also for lithographic work. Bristol first started the trade of printing paper bags. Birmingham does miscellaneous printing for customers all over England. Gloucester is frequently employed to print those fine examples of letterpress work, in black and in colours, which type-founders use as specimens of their most artistic designs. Manchester has printing offices, which might vie with some of the large metropolitan factories. There are no doubt many other towns that might be added to these provincial seats of printing; while in the invention and manufacturing of machines, the provinces have more than held their own with London; and, similarly, it must be confessed that England has in many respects been greatly assisted in mechanical inventions applied to printing by America, France, and Germany.

Though an Englishman had taken out letters patent for a printing machine as early as 1799, the first newspaper printing by machinery and steam was introduced into England by Mr. König, a German. Applegath, Cowper, and Bingham improved upon this, and afterwards Mr. Applegath alone produced a new machine on the vertical cylindrical system, which printed from 10,000 to 13,000 an hour, but on one side only. It was left to Mr. Hoe, an American, to make the next step with "the type-revolving fast printing machine," which threw off 18,000 impressions an hour, and was forthwith built at Manchester, and set up for the 'Times,' which had already been in the habit of duplicating *ad libitum* by the new stereotyping process of Delagana, perfected in the 'Times' office. In the same year that the "Hoe" machine was built, Mr. Applegath had erected a remarkable machine at the 'Standard' office, which by some was regarded as equal to the American invention. Upon both of these, Messrs. Marinoni made a wonderful advance in a machine something upon the Hoe method, but while the Hoe only prints upon one side, and therefore necessitates the employment of two machines for the perfect and simultaneous production of a newspaper, Marinoni's press is a "perfecting" machine, which means that it prints both sides at the same time, and "registers," each page being evenly printed on the back of the other. The 'Echo' is printed on this machine, which has many advantages; among them the facility of easy starting and stopping, and great rapidity of production. This is of much importance in a paper like the 'Echo,' where the over printing of a given number entails great loss. When there is a special demand, additional copies are often printed, while the news-agent is waiting. The machine is turned on according to the orders, as they come in; and this peculiar facility of production is particularly needful for the numerous editions which are published every afternoon. Then comes that which is regarded as the crowning invention of the day, the "Walter" press, made for the 'Times,' and named after the chief proprietor of that journal.

I propose to give a detailed account of these several machines in the course of this paper; meanwhile it is worthy of remark, that French printing has not been without its useful influence upon our English practice. A delicacy of form in French type, and firmness in the serifs, a beauty of design, and a novelty of ornamentation, always characterized French type. The innate artistic taste of the Frenchman, while it moved the type-founder to the recognition of new designs for type and borders, for head and tail pieces, and for initial letters, also actuated the French printer in his work. In books, handsome margins, good paper, and clear impressions as smooth as copper-plate, were characteristic of French printing. Until lately, no English printer ever thought of working on dry paper, though the French had almost always done so in the case of very fine work; in addition to passing the sheets through rollers to remove the impression marks, and brighten the surface of the paper. In England this result was obtained, in a minor degree, by hydraulic pressure of the work between glazed boards, and, except in first-class offices, the rolling is still a new practice to English printers. Germany has done some wonderful things in the way of printing, and sends out every week from Leipzig the best printed illustrated newspaper in the world. Without being in the secret of the mode of its production, I should conclude that the copies which I have seen are printed on dry paper and afterwards rolled. I see no reason why our English illustrated journals, as they pass from the printing machine, should not be run through steam rollers *en route* for the folding machine. The improvement in the appearance of both the typography and the cuts would be enormous, and looking at the great cost of the present production of the 'Illustrated London News' and the 'Graphic,' and the general excellence of their art work, the additional expense of rolling would not be seriously felt in a financial point of view; while the improvement would be palpable to the most unpractised and untechnical eye. Another feature of Continental offices, which has latterly had an influence at home, is the light and airy character of the machine rooms. In England, while we take pains to secure good and proper light for our compositors, it is too much the practice to put the machines anywhere, generally in cellars, where the artificial light of gas is necessary both night and day. Now for fine printing the machining should be done where there is plenty of light, so that each sheet can be examined critically, as to colour, impression, and register; and it is noticeable in the arrangement of modern printing offices, that regard is now paid to these necessities for the production of really good work. America has not laid herself out for what we call fine printing, though the excellence of the newspaper printing of the country is remarkable. Like the French, American printers use particularly good paper for their journals, and they are enabled to do so on account of the higher price which they obtain for their newspapers, in comparison with England.

Coming to the details of the history of machine printing (it would be superfluous to give a history of hand presses), it is only just to give the credit of the first ideas to Mr. Nicholson, who took out letters patent for printing by machinery in 1790. His plan is described as consisting in forming the types with a tapering body or stalk, in order that they might be placed on the surface of a cylinder, and kept compact like the voussoirs of an arch. The type was placed on the surface of a cylinder, and the ink was distributed by means of stuffed rollers or brushes. Though the invention was never perfected or made available in any way, Mr. Nicholson suggested the principle of cylinders and inking rollers, which may be called the foundation of all machines. 'Blackie's Popular Encyclopædia' has an account of the first adaptation of Mr. Nicholson's cylindrical principle, though it is quite possible that the German inventor never heard of Mr. Nicholson or his patent. The roller which followed the old system of inking forms, must have suggested to many practical printers the idea of cylindrical printing. Some ten years after the registration of Nicholson's patent, one König, a printer in Saxony, turned his attention to the improvement of the printing press, with a view chiefly to accelerate its operation. By numerous experimental trials, and with the assistance of another German named Bauer, he at last produced a machine for printing, which, with modifications and improvements, stands, both with respect to ingenuity of mechanism and importance of application, in the first rank of the monuments of human intelligence. Being unsuccessful in all his applications to the printers and capitalists of his native country, for assistance to bring his scheme into operation, he came to London in 1804. There he was, for a considerable time, received with equal coldness, until he met with Mr. Bensley, who had the sagacity to perceive and the boldness to adopt the views of the ingenious Saxon. Mr. Bensley and his co-partner Mr. Taylor (a printing company in which the celebrated Woodfall had, till a short time previous, held a share) made numerous attempts to bring the machine into operation, and ultimately succeeded in completing a model, the action of which so satisfied Mr. Walter, proprietor of the 'Times' newspaper, that an agreement was entered into to erect two machines to print that journal. These machines were accordingly built; but so secret was the matter kept, that the public knew nothing concerning it until, on the 28th of November, 1814, the reader of the 'Times' was informed, that he held in his hand a paper printed by machinery, moved by the power of steam. This is commonly supposed to be the first specimen of printing executed by steam machinery, but a machine was set to work in April 1811, and 3000 sheets of signature H of the 'Annual Register for 1810' were printed by it. This was undoubtedly the first work printed by machinery. The machine, of which I am speaking, was only capable of printing the sheet on one side, and the distribution of ink was unequal, the inking rollers being covered with leather instead of the composition of glue and treacle, formerly alluded to. These imperfections were rectified, and improved machines were offered for sale by Messrs. Bensley and Co. in 1817. This machine performed its work very well, and although it has given place to machines of a more simple construction in the minute details, yet the leading principles are followed in the construction of the machines of modern date.

Messrs. Applegath and Cowper made an improvement upon this machine, whereby the speed of production was increased to 6000 an hour; and a further development was afterwards made by Mr. Applegath himself, by which from 10,000 to 13,000 copies of the 'Times' were turned out. In 1848, the machine was used in several of the largest offices. In 'Tomlinson's Cyclopædia of Useful Arts and Manufactures,' it is thus described:

"The inking table and the columns of type are secured to the surface of this drum; the columns of type are placed vertically, not conforming to the curve of the drum. This is contrived in the following manner. A slab of iron is curved on its under side, so as to fit the large cylinder, while its upper surface is fitted into facets, or flat parts, corresponding in width and number to the width and number of the columns of the newspaper. Between each column there is a strip of steel, with a thin edge, to print the 'rule,' the body of this strip being wedge-shaped, so as to fill up the angular space left between the columns of the type, and to press the type together sideways, or in the direction of the lines; the type is pressed together in the other direction by means of screws, and is firmly held together. The surface of the type thus forms a portion of a polygon, as already noticed; and the regularity of the impression is obtained by pasting slips of paper on the paper cylinder. The large central drum is surrounded by eight cylinders, each about 13 inches in diameter, also with vertical axes. They are covered with cloth, and upon them the paper to be printed is carried by means of tapes. Each of these cylinders is so connected with the central drum, by means of toothed wheels, that the surface of each must move with the same velocity as the surface of the drum. It will thus be evident that if the type on the drum be inked, and each of the cylinders be properly supplied with a sheet of paper, a single revolution of the drum will cause the eight cylinders to revolve also, and produce an impression on one side of each of the sheets of paper. But for this purpose, it is necessary that the type be inked eight times during one revolution of the drum. This is accomplished by means of eight sets of inking rollers—one for each paper cylinder. The ink is held in a vertical reservoir (supplied from above), formed of a ductor roller, against which rests the two straight edges connected at the back, so as to prevent the ink running out. It is conveyed from the ductor roller by one of the inking rollers in the following manner: As the inking table on the revolving drum passes the ductor roller, it receives from it a coating of ink, and then coming immediately in contact with the inking rollers, it inks them; the types next follow and receive from the inking rollers their coating of ink; and the drum, still revolving, brings the inked type into contact with the paper cylinders, and the sheet is printed. It must not be forgotten, as one of the distinguishing features of this machine, that the various processes which have just been enumerated for one set of inking rollers and one paper cylinder are repeated eight times for every single revolution of the central drum, so that in this period eight sheets are printed and turned out of the machine. For this purpose it is necessary to supply the eight cylinders each with a sheet of paper. Over each cylinder is a sloping desk, upon which a number of sheets of white paper are placed. The layer-on stands by the side of this desk, and pushes forward the paper, a sheet at a time, toward the tape-fingers of the machine. These tapes seize it and draw it down in a vertical direction, between tapes, in the eight vertical frames, until its vertical edges correspond with the position of the form of type on the drum. When in this position its vertical motion is arrested for a moment; it then moves horizontally, and is carried towards the printing cylinder by the tapes. Passing round this cylinder, it is instantly printed. It is then conveyed horizontally by means of tapes, to the other side of the frame, and is moved along to another desk, where the taker-off pulls it down. As soon as the sheet is thus disposed of, accommodation is made for another; and as each layer-on delivers to the machine two sheets every five seconds, sixteen sheets are thus printed in that brief space; and this is continued for any length of time, supposing no accident occurs, such as a sheet going wrong, in which case it is the duty of the taker-off to pull a bell handle, and the machine is instantly stopped by the engine-man. As the type form on the central drum moves at the rate of 70 inches per second, and the paper to be printed moves at the same rate, if by any error in the delivery and motion of a sheet of paper it arrive at the printing cylinder 1-70th of a second too soon or too late, the relative position of the columns on one side as compared with those on the other side of the paper will be out of register by 1-70th of 70 inches,—namely, one inch—in which case the edge of the printed matter on one side will be an inch nearer to the edge of the paper than on the other side. . . . . All the layer-on has to do is to draw forward the sheets so, as always to have the edge of one ready for the machine to take in. If the steam-engine which works the machine be put on a greater speed, the central drum, and all the attendant apparatus, would work with greater rapidity; and such a speed might easily be obtained, as to render it impossible for the layers-on to present the paper fast enough to satisfy the improved appetite of the machine; but in any case the machine would not take in the sheets as the layers-on choose to present them, but only at those periods, rapidly recurring though they be, which are provided by the peculiar functions of the machine."

Messrs. Hoe and Co., of New York, superseded this remarkable machine with a still more wonderful contrivance, already mentioned as "the type-revolving fast printing machine," made with two or more impression cylinders. It is carefully and completely described as follows in 'Blackie's Popular Encyclopædia':

"A horizontal cylinder of about 6½ feet in diameter is mounted on a shaft, with appropriate bearings; about one-sixth of the circumference of this cylinder constitutes the bed of the press, which is adapted to receive the form of types; the remainder is used as a cylindrical distributing table. The diameter of the cylinder is less than that of the form of types, in order that the distributing portion of it may pass the impression cylinders without touching. The ink is contained in a fountain placed beneath the large cylinder, from which it is taken by a ductor roller, and transferred, by a vibrating distributing roller, to the cylindrical distributing table; the fountain roller receives a slow and continuous rotatory motion, to carry up the ink from the fountain.

"The large cylinder being put in motion, the form of types thereon is, in succession, carried to each of the six corresponding horizontal impression cylinders, arranged at proper distances around it, to give the impression to six sheets, one introduced by each impression cylinder. The fly and feed boards of two of the impression cylinders are similar to those on the well-known double-cylinder press; on the other four the sheet is fed in below and thrown out above. The sheets are taken directly from the feed board by iron fingers attached to each impression cylinder. Between each two of the impression cylinders there are two inking rollers, which vibrate on the distributing surface while taking a supply of ink, and at the proper time are caused to rise, by a cam, so as to pass over the form, when they again fall to the distributing surface. Each page is locked up upon a detached segment of the large cylinder, called by the compositors a 'turtle,' and this constitutes the bed and chase. The column rules run parallel with the shafts of the cylinder, and are consequently straight; while the head, advertising, and dash rules are in the form of segments of a circle. A cross-section of the column rules would present the form of a wedge, with the small end pointing to the centre of the cylinder, so as to bind the types near the top; for the types being parallel, instead of radiating from the centre, it is obvious that if the column rules were also parallel, they must stand apart at the top, no matter how tight they are pressed together at the base; but with these wedge-shaped column rules, which are held down to the bed, or 'turtle,' by tongues projecting at intervals along their length, and sliding in rebated grooves cut crosswise in the face of the bed, the space in the grooves between the column rules being filled with sliding blocks of metal, accurately fitted, the outer surface level with the surface of the bed, the ends next the column rules being cut away underneath to receive a projection on the sides of the tongues, and screws at the end and side of each page to lock them together, the types are as secure on this cylinder as they can be on the old flat bed.

"A machine of this description with six impression rollers, will throw off 10,000 impressions each hour.

Six persons are required to feed, one for each impression roller. A very large machine upon this principle was made for the 'Times' newspaper by Whitworth of Manchester, and put in operation in July, 1859. It has ten impression rollers, and, consequently, requires ten men to feed in the paper. It throws off at the rate of 18,000 impressions per hour. In May, 1859, a machine made by Applegath for the 'Standard' newspaper was started. It has five impression rollers, placed horizontally, as in Hoe's machine, but presents this peculiarity, that *two men* are required to feed in paper to each impression roller. By this arrangement the machine is rendered capable of producing 20,000 impressions each hour."

The next step in the improvement of mechanism for printing is a much wider one than that which induced the 'Times' to displace Applegath's machine for that of Hoe, though the Walter press is only a further development of the first idea of rotary printing. It is a perfecting machine, and is fed with a continuous roll of paper, whereby the manual labour of laying on the sheets is dispensed with. There are less inking rollers and fewer blankets than in most other machines. A roll of paper, about 4 miles in length and weighing 6 cwt., is placed at what may be called the feeding end of the machine. It is damped in the process of unrolling, and, as it is printed, is cut into sheets and delivered at the other end of the machine at the rate of 12,000 an hour. The sheets are not taken off, but are delivered upon two boards alternately. There are two boy minders who watch the work at the boards, and these, with a third who starts or stops the machine and generally superintends it, are the whole of the staff necessary for its management and working. The 'Times,' quoting a description of the machine of the 1st February, 1872, explains technically the manner in which the printing is done:

"The paper is fed from the reel into a series of small cylinders, where it gets damped, and is then brought between the first and second of four cylinders raised perpendicularly above each other. The top cylinder is encircled by stereotype casts from four pages of type, and the lowest of the four cylinders is similarly surrounded by stereotype plates of the remaining four pages of the newspaper. The paper, in passing between the first and second cylinders, receives the impression on one side. It then passes backwards between the second and third cylinders, and resumes its forward direction in passing between the third and fourth cylinders, from the latter of which it receives an impression from the stereotype plates on the side of the paper, exactly opposite the part printed by the top cylinder. The paper continues its course onwards till it passes between two cylinders exactly in the centre of the machine, where, by a very ingenious contrivance, it is cut into sheets, each forming a complete newspaper. Adjoining the cutting cylinders is an index, which counts each sheet as it is cut. After the cutting is accomplished, the sheet is led forward by a set of tapes, till it reaches the apex of the triangle formed by the left portion of the machine. From this point it descends perpendicularly, and the sheets are thrown alternately forwards and backwards on to the boards held by the two lads. The series of rollers to the left of the reel, and a similar series on the left of the upper printing cylinder, supply and distribute the ink, which is pumped up by mechanical contrivances from a cistern placed beneath the floor. The speed of the presses of the old construction was governed by the limit of dexterity in the layer on, and as, for all practical purposes, he could not feed in more than from thirty to thirty-two sheets per minute, it was only possible to get the power of printing large numbers by multiplying the impression cylinders for each type-bearing surface. But when beyond four, or, at the outside, six impression cylinders in a press are reached, the complication becomes objectionably great. The stoppages are frequent, the waste excessive, and the risk of accident to the machine and material formidable. The working cost of such machines must be heavy, and the working cost is the essential thing to consider; especially when the circulation of a newspaper rises beyond the producing power of one press, and it becomes necessary to duplicate, triplicate, and quadruplicate, to meet the demand. The speed of the Walter press being, on the other hand, independent altogether of manual dexterity, and regulated solely by mechanical appliances, is capable of increase in a way that no printing machine on any other principle can possibly be. Experiments have shown that the machines can produce excellent work at the rate of 15,000 and even 17,000 complete copies of an eight-page paper per hour."

This machine was shown at the London International Exhibition of 1872. Her Majesty's Commissioners not publishing any reports on the different departments, the Council of the Society of Arts undertook this important duty, and in their most useful 'Journal' we have a more detailed description of the process of separating the sheets as the roll is printed. There are two blank cylinders, the circumferences of which are of a length of the open sheet of the 'Times,' or of some integral sub-multiple of this length. Between these the printed web of paper is passed on its way from the printing cylinders to the tapes by which it is to be distributed ready for circulation. Assume that the circumferences are of the exact length. In one of these cylinders is a deep fluting parallel to the axis—this is a sheath into which the edge of what we must call a knife enters. In the other cylinder is a projecting knife (to be described hereafter), having on each side of its entire length a copper guard, formed like one-half of the letter T. This angle-guard is held in projection by springs. If pressure is exerted on these copper guards, they are depressed, and the knife exposed. When the pressure is removed, the springs recover their position. Assume now that the guard is approaching the deep-fluted roller, it will be depressed, and between it and the upper roller will be momentarily held, not stationary, but in its travel, the web of paper. With a rapidity too great for the powers of vision the knife acts, the other side of the cut being held by the other spring. The foregoing description assumes that the separation is complete. It is not so. The knife is not one continuous blade, but is formed of long angular projections; these perforate the paper much closer, but as cheques are sometimes separated from the counterfoils, indeed, similar to the divisions in the postage stamps, but so that the pieces which hold the stamps in sheets are separated. Near each marginal end a narrow joining of the paper is actually left. These two joinings are utilized thus. It is essential that the travel of the paper should always be with its marginal edge parallel to the medial line of the machine. When the cut has been effected, the paper is delivered from the machine to the carrying tapes. To secure the parallelism on its entrance into these tapes, the normal character of the paper is preserved by means of these narrow joinings, and therefore, as a web, it is advanced until the grip of the tapes between two rolls, travelling at a higher velocity than the web, is sufficient to draw the web forward, and so separate the end shreds by which the sheet still retains connection with the original roll of paper. Not only is the sheet thus completely separated, it is actually drawn in advance about two inches. The tapes carry on the sheets to an oscillating taped frame, which delivers them first on one side then on the other of long wooden fingers, which lay the sheets on two tables prepared for them. Whilst the aforesaid blank two inches of tapes are passing, the oscillating frame moves from side to side of these fingers. If the machine were worked up to its full speed, more than three papers per second would be delivered upon these tables. The effect of the cutting arrangement, previously described, the form of the edge of the knife, and the position of the shred-holdings, may be traced by anyone who carefully examines either of the lower edges of the 'Times' or 'Mail.'

The Walter machine was one of the mechanical wonders of the Exhibition. The 'Mail' was printed upon it, and close by was Marinoni's "rotary six-feeder perfecting press," used daily for throwing off part of the fourth edition of the 'Echo.' The 'Journal of the Society of Arts' gives also a brief account of this machine.

The type on which Messrs. Marinoni have based their improvements, is that of the American machine called "Hoe's." Twenty thousand copies of the 'Echo' were printed per hour, though it should be borne in mind that the 'Echo' was a half-sheet newspaper, and printed in duplicate. The delivery of such a stream of paper on one table was a great difficulty, which was overcome in this and the Walter machine, by oscillating frames of tapes. There are slight differences in the application of this method in the two machines, but no remark upon them is needed here. The effect of the oscillating frames is to divide the stream of printed papers, and then, by the usual method of tapes and mechanically-moved *fingers* or *flyers*, the papers are delivered upon different tables. In the Marinoni machine there are three sets of these oscillating taped frames. The first divides the stream of papers right and left, alternately: each of these streams is again divided, so that the printed matter is finally deposited on four tables. In the Marinoni machine, the paper for the 'Echo' was printed in double sheets, the divisions being accomplished by means of a rotating circular knife in the middle line of the machine. This knife cuts in the line of travel of the paper; that in the Walter press cuts transversely to this line of travel. If a suggestion to those who have so perfected newspaper printing as the designers of the Walter and Marinoni machines have done may be made, it would be that the former would perforate, much as postage stamps are, the line of fold (an adaptation of the present ingenious contrivance would do this); and, further, that by the delivery of the sheets to folding machines, the somewhat clumsy arrangement of *flyers* might be dispensed with. There seems no reason why the operation of printing should be attended with so much noise; careful formation of cams, true forms to teeth of wheels, and good workmanship, especially in joints, would materially reduce an element which often proclaims a tremulousness in the machine, and, as a consequence, a falling short of perfection in the work done by it, and a profitless waste of power. That the inking arrangements are even yet imperfect, is deducible from the many and various panaceas which constitute variety, and, by those who adopt them, are called improvements; and that the inking problem is very difficult of solution, may be inferred from the somewhat inconvenient arrangements adopted in the Walter machine.

I have but brief space to refer to machines for jobbing printing. Originally printers did not believe in cylinders for fine work, and hence a certain class of printing was, and still is confined to the hand presses known as the Stanhope, the Albion, and the Columbian. In deference to a regulation of the trade union, a given quantity of hand-press work must be done, in strict union offices, though every year brings its new invention for superseding the hand press. As a tribute to the prejudice of printers in favour of the old principle of the hand press, platen machines were invented, giving all the quality of hand-press work with the greater regularity of mechanical distribution of ink and uniformity of impression, combined with the great desideratum of machine speed. Little, if any, improvement, certainly none in principle, has been made upon the Napier platen machine, completed in 1860 for the Bank of England, and used for printing the Indian bank-note. Incidentally, however, I may mention that the Bank of England has comparatively recently erected machinery for bank-note printing, which far supersedes anything that the platen machine can do for them in the way of their peculiar requirements. Nevertheless, the platen machine remains a most valuable press, and many prefer it for the finest kind of book-work. The Maine machine, improved upon by several well-known makers, is still the most popular, the additions by Mr. Bremner being notably valuable; but at the International Exhibition of 1872, there were five different jobbing machines, which may be said to mark a new era in the history of this class of printing. They are American inventions, and had already become familiar to printers from having been long used in several well-known establishments. I refer to the various kinds of treadle machines, which are being largely manufactured in England. The machines are set in motion with the foot by a treadle, similar to that used for a turner's lathe. In most cases the person who treadles lays on, and when there is not a self-acting delivery, he takes off as well. An intelligent apprentice can soon be made to work any one of these machines, and for circulars and jobs of small numbers, they are indispensable to the general printer. The treadle brings to mind another kind of power most valuable to small printers, who find steam a difficulty because they cannot always have their machinery in full work. I mean the gas-engine. The power can be turned on or off at pleasure, with as much ease as turning on the gas in an office, and the advantage is that the moment the machine stops, the cost of fuel is also for the time being at an end; while, on the score of cleanliness and convenience, the engine is without competition.

Stereotyping, which is the reproduction *ad libitum* of types in metal, is only next in importance to steam machinery as a means of the cheap production of books. William Ged, a goldsmith of Edinburgh, first attempted stereotyping in 1729. He afterwards took William Fenner, a London stationer, into partnership; and eventually Mr. John James, an architect, Mr. Thomas James, a letter founder, and Mr. James Ged, the inventor's son, were also introduced into the scheme, and formed themselves into a company. They were commercially unsuccessful, owing, no doubt, chiefly to the jealousy of working printers, who saw in stereotyping what they regarded as a fatal facility for production. Ged died poor in 1749, and thirty years afterwards, without knowing anything about him or his work, Mr. Tilloch of Edinburgh discovered the art of stereotyping, and when he was made acquainted with Ged's scheme, with the assistance of Mr. Foulis, printer to the University, he improved upon it; a French printer also introduced it into France; and finally, Earl Stanhope, whose printing press had made him famous, patronized the invention, and through his influence and enterprise this aid to printing was practised all over the world. The moulds were made with plaster of Paris. In recent years the French improved upon this in every way. They took the impression from the type with moistened layers of paper, which were afterwards heated and hardened, and from this they took a stereotype cast. Messrs. Delagana introduced this system into England, and it completely superseded the old plan. It is also peculiarly valuable in this respect; paper moulds can be taken and stored, until it is necessary or desirable to pour in the metal and take the plates; and this frequently saves the necessity and expense of keeping type standing. The 'Times' and many other newspapers and periodicals are printed from stereotype casts; while a modern process of electrotyping also gives a reproduction of wood engravings, which in its way is of equal importance, as a means of rapid and consequently cheap production of illustrated works.

Setting type by machinery, and the consecutive numbering *of cheques*, notes, tickets, or other subject matter, confined to ordinary printing, represent two dreams of enthusiastic printers which remain to be fulfilled; and these seem to be both fairly on the way to a happy and complete realization, unless the natural difficulties of type-setting are such as cannot be overcome. The composing machine has its limits; while the printing press seems capable of the most marvellous advance. At the Paris Exhibition of 1855, was exhibited the nearest approach, up to that date, of a composing machine. The letters were arranged in such a way that they could be commanded by keys like those of a piano, which brought each letter from its proper receptacle, and arranged it in a combination of words and sentences. Several machines upon this principle were exhibited; but it was generally agreed that the invention which approached nearest to perfection, was one entitled "Machine à composer et mettre bas pour l'usage de l'imprimerie, composée et exécutée par Christian Sörensen." Mr. Knight thus describes it:

"The types are of the usual thickness and height. In the centre of each type, in the front, is a deep nick of a dovetail shape, which fits upon a metal edge, so that the type cannot be displaced. But of 111 letters which are required in the fount, each letter has two, three, or four nicks cut at right angles, the nicks of no one letter being the same as another. A cylinder, which may be described as a large basin, has a number of metal edges placed vertically in its side, upon which the types, without any regard to order, being the matter *for distribution*, are rapidly slid by the dovetail nick.

"When the basin is filled, it is inverted upon a cylinder of corresponding size below. Upon the rim of this cylinder is a separate opening for the reception of each of the 111 letters, but no one opening is like another. The distributing and the composing go on at the same time. The compositor is seated; with a treadle he moves the upper cylinder, which, as it slowly revolves, finds in the lower cylinder, which is stationary, a fit place for every separate letter as it descends by its own gravity to the bottom of each metal edge. The *n* having two broad nicks, one about one-eighth of an inch from its top, the other at the same distance from its bottom, falls into the *n* opening, which having points corresponding, alone can admit it from its similarity of form, while the *u* having four nicks, two broad and two narrow, passes into its own division and cannot be confused with the *n*.

"But whilst this process of distribution is steadily proceeding, without any care but to keep the upper cylinder occasionally supplied with new material for its operation, the process of composition is rapidly going on. The compositor sits before a compact little frame of keys, each key having a connecting wire for each division of the lower cylinder. He strikes a key, and the lower letter is instantly detached and falls into a funnel-shaped receptacle below, where, without being inverted in any way, it runs into a groove, and arranges itself in its proper order, in the line of its fellows. This is a long line of several feet. By an ingenious contrivance, each such line is passed on one side, as it *is completed*, to another workman, who takes up as many letters as will fill the due width of his page or column, and spaces out the words in the ordinary way. I saw 1000 letters thus placed in line in the short space of four minutes, and the spelling and punctuation appeared as correct as in most matter of common composition before it is read. When the necessary loss of time in refilling the cylinders, and through other hindrances, is taken into account, it was stated by the exhibitor that 50,000 types are set up and distributed each day. This gives a rate of about 6000 an hour, which is treble that of the ordinary compositor's rate."

Since the French Exhibition, other machines have been introduced to the trade, and some have been brought into use. A few years ago, Mr. Young constructed a new one which was a remarkable advance upon that of M. Christian Sörensen; the improvements being chiefly in connection with the chief difficulties of these machines, viz. the justifying or spacing out of a line after composition. Mr. Young made a step in this direction; and, at the London International Exhibition of 1872, examples of still further improvements were shown in practical use. Competent judges thought Mr. Hatherley's the most simple and useful. The deficiency, however, in his machine was the relying upon indiarubber strings of variable strength affected by the rise and fall of the temperature. The working was not so swift as, but more economical than the ambitious machine of Mr. Mackie, the great cost of which was from a financial point of view a serious drawback. Even if the men who have devoted so much skill and patience to the perfection of one of the most ingenious of mechanical contrivances should succeed in perfecting the composing machine, there will always be a great obstacle in the way of its achieving the enormous saving which machinery gives, in being continuous in its operations. Already they have succeeded in picking up and arranging type with a rapidity far beyond anything which the fingers can accomplish; but in composing, or setting up type, whether by machinery or by hand, an educated and trained mind must be at work in advance of the mere technical operation of arranging the type. Neither a machine nor fingers can move on more rapidly, than the director of either or both can read the MS. or "reprint" which is to be set up and printed. Now, it is chiefly in the production of newspapers that the composing machine will be most valuable, and as dailies and high-class weekly journals are chiefly set up from manuscript, the compositor must always read his copy with more or less difficulty. The manuscript of some of our best writers is the least easy to read; and unless a machine can be provided with a mind of wonderful acuteness, unless we can find a machine that will think and transcribe difficult copy with a facility far beyond the quickest perception of the best compositor, the speed of composition must always be regulated by the character of the MS. to be set up and the capacity of the man who reads it. There are other difficulties of detail which it is hardly necessary to point out, that may also limit the action of the composing machine; though the setting up of 'The Times Summary,' a book of 598 pages 12mo, by four *lads, working at two* composing machines, in ten days of eight hours, is a feat which promises a revolution in the composing rooms of the future.

There are numerous machines which may be said to have solved the difficulty of consecutive numbering; but only two, I believe, which claim to combine this advantage with ordinary printing. The first is known as Bebro's patent, for the working of which a company was formed under the Limited Liability Act. The machine is an ingenious contrivance. The consecutive numbering is accomplished by an enormous grooved cylinder upon which the figures are placed. While the ticket is being printed from a continuous roll, the numbering cylinder is revolving beneath a series of ordinary printing cylinders, and thus impressing the consecutive figures upon each ticket. The feat of printing both sides of the ticket, perforating it, and numbering it consecutively up to twenty or thirty thousand all at one operation is accomplished by this machine, and at a rate not heretofore achieved. The work produced is not always equal in quality, but the numbering seems to be satisfactory so far as it goes. The second machine, which is not yet in the market, is claimed to be the invention of Mr. Simeon Sampson, and supersedes the Bebro patent. It is without doubt a very wonderful contrivance, and is destined to work a great saving in the printing of tickets, cheques, notes, and forms requiring to be consecutively numbered. The principle is a combination of ordinary printing with the hand-numbering machine made rotary, and fitted to work simultaneously with the action of machine printing on a continuous roll of card or paper.

It claims, as its speciality, consecutive numbering to any figure, and in this respect is far in advance of any existing machine; indeed, it may be said to have solved the problem of rapid and economical consecutive numbering in combination with ordinary printing. The Bebro Company and Mr. Sampson went to law not only on the question of alleged infringement of patent, but as to the interpretation of agreements affecting both parties. These proceedings, it is understood, have delayed the introduction of the new machine to the trade, though the Bebro patent is now pretty well known by printers who take note of the march of mechanical science. Whatever may be the success of the second machine, it would seem that the first one has not prospered; for the Bebro Company is being wound up, and its founder has petitioned the Court of Bankruptcy. These consecutive numbering machines have rivals in the market, and though the competing inventions appear to be out of the race in the fact that they do not print, perforate, and number all in one operation, they are in successful operation, which cannot yet be said of the Bebro and Sampson ideas. In the German section at the Vienna Exhibition of 1873, there were several machines for printing and numbering railway tickets. The most complete of these were the production of Herr Zimmermann, of Berlin. He had a machine for printing the tickets with an index to show the number printed, and also a numbering machine, both machines being self-feeding. "The Gandenbergersche Machinen Fabrik," of Darmstadt, had a machine for railway tickets which combined printing and numbering; and it supplemented the printing with an arrangement for packing the tickets in cases. Connected with this branch of printing was a cheque machine by Herr Fritz Jänecke, which prints five numbers at a time, each belonging to a different series carried on consecutively. This activity in the work of consecutive numbering points to a speedy accomplishment of all that can be desired; and in these days of coupons, and the checking of numbers on railway tickets and in retail trade transactions, the importance of these improvements, so far as economy of production is concerned, cannot be over-estimated.

I have not spoken of copper-plate and lithographic printing; and the space at my disposal will only permit me to remark generally, that progress is observable in both these departments, but more especially in the art of lithography. The most ordinary person will be able to gauge this in the way of results by a glance at the railway station advertising walls, not to mention the coloured illustrations in the cheap as well as costly works of the day. But the most important change in lithographic machinery during recent years is that made by Mr. C. Maurice, of New York, who has superseded the flat lithographic stones. It is necessary to explain, that in lithographic printing the transfer from copper plate or direct from the artist's own pen is made upon a flat stone, which is subject to treatment in the way of inking and pressure, analogous to, though widely differing from, letterpress printing, and in the matter of speed, as far behind letterpress printing as the coach is behind the locomotive. Mr. Maurice has made an advance of great value towards faster working, by using cylinders instead of the ordinary flat stones. With suitable diamond tools, he drills the stones, and the cylinders thus formed are, in the small presses, mounted on bearings carried by a pair of standards, which also carry the bearings of a metal roller placed below the stone cylinder, and capable of being forced upwards upon the latter by means of a screw and band-wheel. The cylinder and metal roller have between them a sheet of thick leather which carries the paper, and the operation of printing is exceedingly simple. Transfers upon the stone are effected with remarkable facility. At the Vienna Exhibition, Mr. Maurice exhibited one of his largest machines. It had a stone cylinder 28 inches by 20 inches, and using endless-web paper. There was a self-acting water-feeder and inking arrangement. The work produced is equal to the best machine lithography, and the machine will throw off 7000 copies per hour. Mr. Maurice is making experiments with a view to newspaper and periodical printing by this process, taking a transfer of the type upon the 6-stone cylinders; but I cannot see what possible advantage he can anticipate, in a competition with this class of printing. In jobbing work he might hope to turn out, at a slightly increased price, work far beyond letterpress in style and appearance; but speed is the secret of newspaper printing, and in this direction he must fall far behind the Walter, the Victory, and the Marinoni. Indeed, it seems absurd to attempt the development of a lithographic machine in the direction of newspaper printing.

While English printers have been directing their attention chiefly to the cheapening of production, France, Russia, Austria, Belgium, and Bavaria have carefully maintained, if they have not improved upon, the beautiful printing which obtained in the good old days of folio books and expensive work. This was particularly evident in the printing department of the London International Exhibition of 1872, and also at Vienna in the year following. The remarks that apply to one may be made of the other, and, in regard to London, we may fairly endorse the Society of Arts' report. In bookwork and commercial printing, some of our most famous firms, such as Gilbert and Rivington; Whittingham, Wilkins, and Co.; R. Clay and Co.; Cassell, Petter, and Galpin; Virtue and Co., and others, well supported their reputation; but there were contributions from Continental co-workers superior to that of England. His Russian Imperial Majesty's Chancellerie exhibited most valuable material, and especially one volume sent in by the Imperial Academy of Science, containing Our Lord's Prayer, printed in 356 languages. A splendid specimen of typography, this book more than rivalled the important display of the British and Foreign Bible Society, which exhibited translations of the Scriptures, printed in 202 of the living languages of Europe, Asia, Africa, and America, and the islands of the Pacific. Rivingtons stood alone "in their new unimprovable movable types for embossing; and if these great printers had no other evidence of their skill, their types for the blind would crown them with the highest honour." Apropos of printing for the blind, I may mention that I was the first, associated with the Rev. J. Blair, of Worcester, and at his suggestion, to introduce into England embossed printing from the ordinary Roman type, the result of which was the formation of the Worcester Society, in which we were assisted by the Bishop of the diocese and some local gentlemen. The idea was, to perpetuate among the blind the ordinary Roman type instead of hieroglyphics, so that the educated blind may read to the ignorant who can see, and that the blind may gradually have a share in the common literature of the land, and not remain cut off, as it were, from the world by a separate printed language. The result has been the successful establishment of a college on this principle, and, in due time possibly, the general adoption of embossed Roman books. The upholders of hieroglyphics, in which there is an immense vested property, are severely critical of the new system. Our only hope is that, between the two, the blind will have books printed on whichever is really the best and most useful system of typography.

This brings me to bookbinding, of which it is only necessary to make a few general observations. Cheap printing necessarily demands cheap binding, and by degrees machinery has come to the aid of the worker in this outside branch of the printer's art. One of the most remarkable instances of quick binding on record, is that of the Official Catalogue of the Great Exhibition of 1851. At 10 o'clock at night, on the 30th of April, the printer handed over to the binder the first complete copies of this great and interesting work. At noon the next day 10,000 copies were being sold in Hyde Park, while two copies separately bound for Her Majesty and Prince Albert were delivered to the Exhibition Commissioners. The most beautiful specimens of modern bookbinding were also exhibited on this occasion, and I question whether anything has been since seen to equal them. In their report, the Jury noticed in the following terms the advance which had been made in the way of expediting the binding of books:

"Mr. Burn, of Hatton Garden, first introduced rolling machines to supersede hammering. The iron printing presses of Hopkinson and others were altered to form arming presses, by which block-gilding, blind-tooling, and embossing can be effected with accuracy and rapidity. Leather covers, embossed in elaborate and beautiful patterns by means of powerful fly-presses, were introduced by M. Thouvenin, of Paris, about twenty-five [now nearly fifty-five] years ago; and almost simultaneously in this country by Messrs. Remnant and Co., and by Mr. De la Rue, who were quickly followed by others. Embossed calico was also introduced about the same period by Mr. De la Rue. Hydraulic presses, instead of the old wooden screw presses; Wilson's cutting machines, which superseded the old plough; the cutting tables with shears, invented by Mr. Warren De la Rue, and now applied to squaring and cutting millboards for book covers,—all these means and contrivances, indispensable to large establishments, prove that machinery is one of the elements necessary to enable a binder on a large scale to carry on that business successfully."

An important improvement also was the introduction of a cement or glue, instead of sewing, for fastening the sheets of books together. In this process all the edges are cut, the leaves being all separated. The leaves for a volume are placed in a gauge, by which convexity is given to the back edge, and concavity to the front. The cement is then applied to the back edge, whereby all the leaves become cemented together. The result is a flexibility on the opening of a book, most comfortable to the reader of a thick volume; but, to secure permanence, it is necessary that a few stitches should be made. Another kind of cement is also in use, and this has been since supplemented with what is called Palmer's Patent, described by Mr. Knight as another mode of attaining the result carried out in the indiarubber binding. Since then, Mr. Williams and others have introduced numerous changes and improvements in machinery and implements for binding; while by degrees, nothing is really left to hand-work, except sewing and the finishing of the highest class of leather work. At Messrs. Virtue's establishment, the only one in England where the entire work of book printing is done on the premises, including engraving, wood and steel (if we may except Cassell's, who have many of their books written as well as printed at "the Yard," and by the yard), may be seen at work some of the newest descriptions of bookbinding machines, more especially those referred to in the Society of Arts' Report of the London Exhibition of 1872:

"One of the heaviest and most troublesome manual operations in the trade used to be the rounding of the *backs, which was effected* by means of heavy hammers, and could only be well done by very experienced men; the back of the book, before being covered, was dressed with glue, and before this was quite set, the convex form was entirely produced by means of the hammer alone. At present the rounding is effected by simple, though powerful machines, the largest of which will give a huge ledger or grand folio volume a perfectly rounded back in a few seconds. The book is nipped in the machine back upwards, and thus held, is passed beneath a fixed bar, backwards and forwards, till the result is obtained. The front and side edges of books are cut by means of paper-cutting machines, instead of the old plough; the hydraulic press is made to do the work of compression instead of the old hammer; and, lastly, the whole of the lettering and ornamentation, of all but the highest class of work, is now done by arming and embossing presses. Three of these arming presses are in the Exhibition, one of them being a large, powerful machine. The cyphers, crest, armorial bearings, &c.—from which the press takes its name—as well as any letterings or ornaments to appear on the covers or back of the book, are engraved on a gun-metal block, or, in the case of the back, the title and ornaments are sometimes cut separately, and fixed down on a strip of paper by means of glue; the cover is then laid on the block and submitted to heavy pressure. If the cover of the book be of leather, the plain ornamentation, or 'blind-tooling,' as it is called, is produced by pressure only, aided by heat, which is obtained from gas burning within the press; but in the case of cloth binding, this blind-tooling is produced by inking the block before each impression. In the case of gold work, leaf-gold is laid over the block, and made to adhere firmly by means of heat and pressure. Press work never produces the beautiful effect of hand-tooling, but the appearance is brilliant, and the cost infinitesimal as compared with that of the latter."

Owen Jones, Sir Digby Wyatt, and John Leighton have laid the foundation of what may be called the modern school of ornamental bookbinding. When Mr. Leighton made the first drawing, a full gilt back was an effort for the press, and he made the first of any size, introducing also the employment of black in conjunction with gold, now so much in use. In the Middle Ages the first artists, Holbein, Albert Dürer, &c., worked on the printers' ornaments and the exterior of books. Mr. Leighton has raised the art of ornamentation above technical difficulties, and the present age of binding owes him a lasting debt of gratitude. It is some years since he patented an improved method of decorating the edges and margin of books and paper, and he was the first to apply hard stamps to the London Post-office Directory.

Leather is still the material *par excellence* for covering a book, and with no other material can so perfect a hinge be made. In flexible binding, leather is essential, vellum and cloth only admitting of hollow backs. It is true that in the Middle Ages, tight backs have been made, but always in combination with the heaviest workmanship and absence of finish, the lettering on the back being put in with pen and ink, the wooden boards left uncovered, and the fore-edge fastened with thongs. Mr. Leighton says, that he has always found the sewing of these books very good. Every sheet is sewn upon the cords or bands across the back, while, in the present day, the bands are mostly delusions so far as strength goes, and the cords upon which the sheets are sewn are inserted into grooves made in the back by a saw, a neat way, but not so durable as the old method. Many books of the mediæval period are bound in vellum and leather without millboards. Formerly a pasteboard was used, made of rude materials. The earliest leather covers were principally of a rich brown calf, undyed, and so they remained until the early part of the present century, all the stains then in vogue being imparted to the skin by the bookbinder. The plain dyes, given to calf on the whole skins, have tended to supersede the colouring of leather on the volume itself. Our modern bibliograph insists that, of all leathers, morocco is the best for the binder's art. The undyed calf is, as a rule, rendered rotten by the use of oxalic acid, to impart delicacy to the surface. Hog skin is not much used, though it is durable, and takes blind-tooling admirably. Russia is unsatisfactory, unless used very thick; if pared much, it is as weak as paper, though it is much prized for its odour and pleasant tone of colour. It is a weakness of modern binding, that leathers are pared down too thin, especially at the joints and head-bands. Of fabrics, silks and velvets have been, and are still used for binding, though they are not susceptible of the highest branch of bookbinding, the decoration by "finishing." In cheap books various coloured calicoes have of late years been used with much advantage, the titles being first printed by letterpress in the ordinary way, either in black or gold. Those of my readers who wish to read up the most reliable and interesting reports and papers on bookbinding and the preservation of libraries, will find some interesting notes in Hunt's 'Reports on the Exhibition of 1862,' Edwards on 'Libraries,' Leighton's 'Notes on Books and Bindings,' reprinted from 'Notes and Queries,' 1858, and the 'Journal of the Society of Arts.'

In the last century, when book collecting was as great a mania in its way as the tulip fancy of a previous time, and the china craze of to-day, the desire for superb and characteristic binding commenced. It was at this crisis that "Roger Payne rose like a star, diffusing lustre on all sides, and rejoicing the hearts of all true sons of bibliomania." Since Roger's days some exquisite work has been done, and worthy efforts have been made in the way of characteristic binding, more particularly in lettering and ornamentation. Roger Payne bound his books in a manner, however, rather "expressive of the high rank" of his several patrons, than in keeping with the character of the books themselves. In modern days, designers have endeavoured to harmonize the binding not only with the printing but the subject of the book, and the exercise of a cultivated taste in so interesting a field of manufacture deserves every encouragement. Circulating libraries and cheap editions of standard and miscellaneous works seem to be detrimental to high-class binding. Men do not take the pride in libraries, which used to be apparent in country houses and bachelors' chambers. There are enthusiastic book-collectors, who get together the best recognized editions of known works; but the desire for building up libraries of favourite authors seems to be dying out. In company with all other manufacturers, artistic and otherwise, bookbinders must adapt their work to the special requirements of the age in which they labour; and this is peculiarly the age of practical science, of applied theories, of mechanical successes; but above all, the age of speed. The spirit of the locomotive has entered the workshops of the world; and the printer and bookbinder should be in the van of its mighty progress—victorious over bygone triumphs, heralds of victories yet to come.

ENGRAVING.

By the late Samuel Davenport (Society of Arts).

Vast and varied are the industries involved in the word printing, employing multitudes of people in carrying on the numerous printworks, and processes connected therewith.

We are apt to think of a print as a simple and inexpensive product, necessitating but little skill and less knowledge on the part of its producer, and this is to a great extent true, if we limit our notice to the men and boys who attend to the working of the machinery employed in the printing of books, newspapers, wall papers, calicoes, and other fabrics. Such a limited view of the printer's art is however highly fallacious, as there are few, if any of the industrial pursuits of the present day, which have called to their aid so large an amount of scientific knowledge, artistic ability, and mechanical skill, as that of printing. Prints on paper, cotton, wood, stoneware, glass, iron, steel, and other metals, are now employed to decorate the surfaces of wares such as are to be met with in almost every cottage, not only in this but in foreign lands; and it is the increased facilities for their production that have added so vastly to the industries and commerce of England. I shall endeavour to point out in the following pages, as briefly as possible, a few of the processes which have been, or are at present employed in printing, limiting the remarks to such as are of a purely mechanical nature, or involve the use of machinery to such an extent, as to have given rise to the term "machine-prints."

It is desirable that it should be understood, that whatever the process may be, the print obtained is the result of one of two conditions, viz. that of a design produced in relief, by removing from the surface of the substance upon which the design is drawn, those portions which surround it; or else, of a design cut into the surface of wood, metal, or some other substance, and which presents an even face.

The discovery of the art of printing is attributable rather to accident than design, and may be supposed to have grown out of the practice, which must early have been introduced, of attaching some distinguishing mark to the works of individual producers; and that such practice existed among the Egyptians we have ample evidence. It has been asserted as not improbable, that amongst the earliest products of man's labour was the plastic clay of the brickmaker to which marks were attached, the mark being made by indenting the soft surface of the brick with the angular corner of one which had been hardened by drying or burning. Mr. Nasmyth has shown how easily the arrow-headed characters, of which we have now so many fine examples in museums, could have been written upon soft bricks by means of a stylus, the point of which would be formed to represent a triangular corner cut from a brick. Thus the brick is supposed to have been the forerunner of the pen, as single marks were of alphabets; and written language thus created soon became the means, by which the histories of past ages were recorded in the sculptured stones of the period. This fact is well illustrated by the Assyrian tablets now preserved in the British Museum. The tablet taken from the palace of Assurbanipal, king of Assyria, at Nineveh, has been recently found by Mr. George Smith to record the story of the flood. The date of these stone records is assumed by Mr. Smith to be about seventeen centuries before the Christian era.

Thenceforward, a refined art sprung up, and attained to a high degree of perfection, of which the ancient gems preserved in our museums give ample proof. Engraving on metal was early employed as a means of ornamenting articles of dress. It is unnecessary here to trace the history and progress of the art of engraving on stone and metals, but as that of printing is based upon engraving, it may be stated that printing from metal plates, as now practised, had its origin in the goldsmith's craft, as printing from wood blocks probably had for its forerunner the bricks of Babylon. In ancient times, and before the introduction of paper, or printing rolls, the forerunners of books were usually written upon strips of the Egyptian plant *papyrus*, wound upon wooden rollers. In the seventh century, after the capture of Egypt by the Arabs, papyrus could no longer be obtained, and the use of skins of parchment became general. The roll was ultimately superseded by the book, which then consisted of a number of sheets of parchment fastened or bound together, forming the leaves. Before the introduction of Christianity, the Jews became very expert in the art of caligraphy; and after monasteries were established, the production of books for the service of the choirs of the abbeys was intrusted to novices who employed their time in the Scriptorum, whilst Missals and Bibles were executed by monks of mature experience and approved skill. The Anglo-Saxon monks were the originators of the small Roman letters used in modern times. After the invention of linen paper, about the thirteenth century, which greatly lessened the cost of the production of books, they continued to be rare and expensive articles, and it was enacted by the Statutes of St. Mary's College, Oxford, in 1448, that no scholar should occupy a book in the library more than one or at the most two hours, "lest others should be hindered of the use thereof."

Previous to the use of separate wood types for printing from, stencil plates were employed in the multiplication of designs, and were subsequently adopted in combination with wood blocks in the printing and colouring of playing cards. The outline of the design was cut in relief upon the blocks, which were then inked and printed, by rubbing paper in contact, and not by direct pressure, as is now the case, colour being afterwards added to parts of the print by means of stencil plates.

For more than a century and a half, after the invention of printing, wood blocks were largely employed in England, France, Germany, and Holland, in the illustration of books, but were subsequently superseded by engraved metal plates. Within the last half century, however, the art of wood engraving has been revived and greatly improved, and is now generally employed in the illustration of periodical literature.

As wood engraving performs an important part in relation to printing, both artistic and industrial, it may be well to state, that for purposes of art, it is usual to engrave the design on blocks of boxwood, a hard, dense, and tenacious wood, which admits of minute subdivisions of its surface, and at the same time is capable of supporting heavy pressures, without crushing or breaking. The designs to be engraved were formerly drawn in lines upon the wood with a lead pencil, but they are now, for the most part, made with Indian ink on a surface of Chinese white. The block, so prepared, is ready for the engraver, who at once proceeds to cut away such portions as are not covered by any part of the design; and next lowers such portions of the surface as are required to yield a comparatively soft impression in the lights of the picture, while the middle tints are obtained by cutting away more or less of the surface in a suitable manner. Where great force and shadow are required, but little of the surface is removed, and occasionally additional pressure is obtained, when printing, by attaching pieces of paper to the back of the block. Box trees seldom exceed a few inches in diameter, so that where large blocks are required, such as are used in the illustrated papers of the present day, they have to be prepared by screwing several pieces together. This apparent disadvantage is not one in reality, as it allows of the drawing, after it has been made by the artist upon the combined blocks, being separated into many parts, each of which may be worked upon by a separate engraver, the whole design being subsequently brought together to be worked over in its entirety by one master hand, so giving unity and finish to the whole. It is this principle of subdivision which enables many of the elaborate and costly works now published, to be produced with such marvellous celerity. The form of graver employed varies with the character of the effect required, but where large portions of the surface admit of being cut away, it is gouged out, the belly of the graver being semicircular, and the end of it U shaped. The facility with which wood blocks take the printing ink, and yield impressions in combination with metal types in the ordinary hand-printing press, had led to their almost universal adoption. The rate of speed at which wood blocks can be satisfactorily worked at the steam-printing press is about 2500 per hour, while type letters may be worked in the modern steam-printing presses at the rate of 20,000, 30,000, and even 40,000 impressions per hour. This difference in the print-yielding power of wood blocks and metal types has led to the use of the hand-printing press, whenever a superior class of printing is required in the production of books; and also to the system of printing from the blocks used in the illustration of our periodical literature on one side of the sheet only, the block sheets being worked at a much lower rate of speed, than the side on which type alone is used.

TYPE FOUNDING AND CASTING.

Separate types followed the introduction of wood blocks, and were multiplied by means of punches on which the letters or designs were cut, the types being cast in soft metals. Punches of a similar character are still used by bookbinders, and, indeed, formerly the printer was both typefounder and bookbinder. In order to show the growth of the printer's art, it may be stated that in 1637, by a decree of the Star Chamber, it was ordered that there should be four founders of letters for the kingdom, and no more, and in 1674 it was enacted by Charles II. that the number of printers should be limited to twenty. Notwithstanding this, it is stated by Moxon, "that in 1686 they had so increased, that for the more easy management of typography, the operators had found it necessary to divide it into the several trades of the master printer, the letter cutter, the letter caster, the letter dresser, the compositor, the corrector, the pressman, the ink maker, besides several other trades which they take into their assistance, as the smith, the joiner, &c." The earliest complete printed work, a copy of which is in the King's Library, at the British Museum, is commonly known as the 'Mazarine Bible,' or the 'Metz Bible.' It is supposed to have issued from the press of Gutenberg and Faust, in 1455. The next book was the celebrated 'Psalter,' printed by Faust and Schöeffer in 1457. The small letters of this edition were printed from metal types, and the capital letters from wood blocks; but Meerman asserts that the type used was cut and not cast, and that the earliest instance of printing with cast type is Durand's 'Rationale Divinorum,' printed with an entirely new fount of type by Faust and Schöeffer, in October, 1459. The casting of types in metal, the matrices of which were formed by means of hardened steel punches in combination with wooden blocks, was the important step by which the art of book printing has been brought to its present state of perfection. Music was probably amongst the earliest examples of printing in two colours; the 'Psalter,' printed at Metz in 1490, was so produced, the notes being printed in black, and the lines in red ink.

Stereotype Printing.—After the discovery of the art of printing from movable types, either of wood or metal, it is probable that no discovery has had so important an influence on the printing industries as that of stereotyping, an art which had for its object the conversion of the sheet, composed of separate types, or types and wood blocks in combination, into a sheet of solid cast metal, which could be handled freely, without risk of injury or error, whenever required. The art of stereotyping was perfected in London, in 1802, by Mr. Andrew Wilson, who is described as of the Stereotype Office, near the Veterinary College, St. Pancras. Mr. Wilson was not, however, the originator of the stereotyper's art, for many have claimed to be considered the originators of that, as of every other successfully applied discovery. As early as 1711, a process was introduced by a Dutchman, Van der Mey, *for* consolidating types after they had been set up, by soldering them together at the back. It is believed that William Ged, of Edinburgh, practised stereotyping as we now understand it, about the year 1725, and attempted to apply his process to the printing of Bibles for the University of Cambridge. The ultimate introduction of stereotyping into common use was, however, principally due to the Earl of Stanhope, who became acquainted with the plans proposed by Mr. Tilloch, the editor of the 'Philosophical Magazine,' who had communicated his plans to Mr. Foulis, printer to the University of Glasgow, and those gentlemen, in association with Mr. Andrew Wilson, carried on their experiments at Earl Stanhope's seat, at Chevening Park, in Kent. The method then employed, and to some extent still in use, was that of taking a cast in plaster of Paris, after the type had been locked in the type forms ready for printing from. Before casting from it, the type was carefully cleaned and slightly oiled, to assist in the delivery of the plaster from the mould. The cast had then to be dried very carefully, so as to prevent it warping. In France, a method known as "striking the mould," had been employed, and consisted in allowing the type forms to be carefully pressed into metal, in a half-melted state, and from the impression so obtained, the stereotype plates were cast, though this process was found to injure delicately cut wood blocks. The late Isambard Brunel appears to have suggested in 1820 the employment of a mixture of pipe-clay, chalk or burnt clay, and starch mixed into a thick paste, which was spread over the surface of a thin and flexible sheet of steel. The composition was then covered with several thicknesses of fine calico, backed with a skin of wet parchment, and was pressed into contact with the type form, after which the calico and parchment were removed and sheets of paper substituted; pressure was again applied, after which it was removed, and the composition finally brought into contact with the type, and from the mould so obtained, stereotype plates were cast. This plan was proposed chiefly in connection with newspapers and similar publications, and in it is involved the first use of paper, which has led to so many important improvements in the practice of stereotyping. About the year 1849, Mr. Klein patented a process for forming the moulds of sheets of damp paper, working them down upon the faces of the type forms by means of brushes, the paper being allowed to dry in contact with the type, and used as a mould from which to cast. As on the first introduction of the system, casts were confined to single pages of type, so, till recently, all moulds of whatever size have been cast as flat as possible, and such was absolutely necessary, as long as the ordinary hand press, or flat pressure by means of steam-printing presses was alone used.

With the growth of population and the abolition of the advertisement and paper duties, however, a vastly increased demand for periodical literature arose, and that demand has been met by the introduction of printing machines, in which the type forms are printed from cylinders. The cylinder machines necessitated an essential alteration in the method of stereotyping, and in the first instance flat paper moulds were taken from the flat type forms, and the stereotype plates were cast from them, the cylindrical shape being afterwards given to the plates by means of hydraulic pressure. Recently, however, the practice has been introduced of casting the stereotype plates cylindrical in form, by placing the flat paper mould in a cylindrical mould box, with the face of the mould upwards, upon which the molten metal is run. Such is the rapidity with which all the operations of stereotyping a page of the 'Times' newspaper are now conducted, that the cast cylinder of type is delivered to the printer ready to be put into the machine, in less than half an hour from the receipt of the type from the compositor. The 'Times' is now invariably printed from stereotype cylinders, the press being fed by continuous webs of paper, of about 3 miles in length, each paper being cut off in the machine after it is printed, and the rate of delivery being from 30,000 to 40,000 copies per hour.

Wood blocks and metal types form, however, but a small portion of the means of preparing printing surfaces, and I shall consider other methods employed in the production of engraved metal plates, or relief surfaces.

The discovery of engraved copper plates is attributed by Vosari to Maso Finiguerra, a goldsmith and engraver of Florence, who, about 1460, is said to have taken impressions upon damped paper, in ink made of oil and soot, from metal plates which he had engraved, and the lines of which engraving were ultimately to be filled in with niello. The discovery is said to have had its origin in the accidental laying of a damp cloth upon an engraved plate, in the lines of which a portion of the oil and carbon, used to try the effect of the work, had been left.

The art of line engraving on copper, and that of etching with which it is now combined, is attributed to Albert Dürer, and dates from the beginning of the sixteenth century.

Etching on metal is effected by first coating the surface of the metal plate with a mixture of bitumen, wax, and other ingredients which resist the action of aquafortis. The design to be etched is then drawn upon the copper by means of a sharp steel point which removes the etching ground, and permits of the design drawn being corroded, or eaten into the metal, by acids, the lines thus obtained being then charged with ink and printed from. A combination of etching with the use of the graver was employed by Hogarth, Bartolozzi, Boydell, Virtue, Heath, and others, whose works gave fashion to the arts at the close of the last and commencement of the present century; but at best the process of line engraving was tedious, costly, and limited as to its capability of supplying the ever-increasing demands for prints, a difficulty which ultimately led to the introduction of engraving on steel. The several processes of engraving, whether on copper or steel, may be thus briefly described.

Chalk or Stippled Engraving was executed upon the metal plates by thrusting the point of the graver into their surface, and by so arranging the punctures as to *form* clusters of dots, which, when printed, gave to the print the appearance of a drawing with chalk upon paper.

Mezzotinto Engraving was probably one of the first processes which had for its object the production of prints, from tints graduating from light to full shadow. The discovery of this process is attributed to Prince Rupert, but the credit of its invention appears to belong more properly to Louis Von Siegen. The process is said to date from 1643. Mezzotinto engraving is effected by puncturing or breaking up the entire surface of the metal plate by means of a rulet and the production of an uniform burr, which is afterwards reduced to various degrees of intensity by scraping and burnishing, thereby regulating the amount of ink capable of being retained in printing from the plate. This process was the one most generally in use when Hogarth commenced his career; it was extensively used in the production of portraits, and afforded richer and fuller effects of gradation from light to shadow than either of the preceding ones, and it is to this that we are indebted for the first attempts at printing in colours from copper plates, introduced by Robert Laurie in 1777.

Aquatint Engraving is effected by coating the surface of the metal plate with finely granulated resin, or by pouring resin dissolved in spirit over the plates. After the spirit has evaporated, the film of resin contracts and becomes minutely reticulated. The surface of the metal, which is thereby partially uncovered, is then sloped out where the high lights of the engraving are to be preserved, after which it is submitted to the corrosive action of acid, the degree of corrosion being regulated, so as to produce lights and shadows in the print. This process afforded great facilities for covering large surfaces, and soon became extensively adopted for panoramic and other views; indeed the majority of the coloured prints on a large scale were thus produced at the beginning of the present century. Line, chalk, aquatint, and machine engraving were in some instances combined in the case of prints of large dimensions, as they could all be worked upon one plate, and printed from in the same manner; indeed they were in common use, when Senefelder discovered the art of lithography.

The coloured prints, obtained from plates engraved by the above processes, resulted from filling in various parts of the plates with differently coloured inks, the plate being protected from receiving the ink in the wrong place, by means of a paper mask or impression laid over it. This kind of printing was called thumb printing.

Lithography was discovered by Alois Senefelder in 1795. The principle upon which it is based, is that of giving to certain portions of the surface of a highly polished slab of limestone, an affinity for the greasy matters of which printers' ink is compounded, at the same time that other portions of the slab repel it. This is done by making a drawing upon the stone with a greasy crayon, the grease being absorbed into the surface of the stone. In order to print from the stone, the surface is wiped with a wet sponge, a portion of the water in which is absorbed into it and serves to repel the grease of the printing ink, when applied by the inking roller, whilst the portions covered by the drawing take up the ink, which is given off to the paper when pressure is applied in the printing press. The process was soon practised in Germany, France, and throughout the continent of Europe, but was not used in England until about the year 1819, and then for many years little more was attempted than printing in black or tinted inks. The earliest example of chromo-lithography produced in England, was a view of Claines Church, Worcestershire, printed by Messrs. Hanharts, but as chromo-lithographic printing is now so largely employed, a somewhat fuller account of the process may be given. Prints from a drawing made upon a lithographic stone, depend for artistic effect and force of light and shadow upon the skill with which the drawing is graduated, and the surface of the stone made to repel or attach the ink.

Many modifications and treatments of the stone were early introduced, but the use of a greasy crayon was the one first generally employed, although stumped and washed tints called litho-tints soon followed. The early attempts to print in tints from lithographic stones were a great advance upon the processes of colour-printing from engraved metal plates, but, great as it was, the art has made still greater since tint printing was adopted, and black ink abandoned in the production of chromo-lithographs. The successful and economic production of a chromo-lithograph depends mainly upon three points; 1st, the skill with which the lithographic artist analyses the colours employed in the production of the picture to be copied; 2nd, the number of stones employed to print from; 3rd, the skill of the printer in mixing and applying his ink. Chromo-lithography may be described as a mechanical process of mixing colours by the superposition of one tint upon or beside another, and just in proportion to the number of stones employed in this mechanical mixing, will be the gradation from light to shadow, and from tint to full colour. The process employed in the preparation of the stones from which the picture is to be printed, consists first in the artist setting a definite limit to each tint or colour to be employed. This is effected by making an outline drawing upon paper, which drawing is transferred to the stone, and becomes the key to the preparation of all the various stones required to yield the different tints.

The stones having been arranged, next comes the preparation of the ink, which requires the utmost care and skill, and it is not till after a succession of trials and errors, that the precise tint of colour is attained. This is at last determined by cutting out those portions of the outline print, representing the colour to be printed, and then using the print as a mask over the picture, thereby avoiding the influence of local colour upon the eye, while the tint is under examination. When the tints printed from stones are as nearly as possible identical, either in their separate or combined effects, with the tint of the picture, the stones are ready for working at press. The lighter tints are first printed, and the fuller colours and shadows follow in their prescribed order, the whole resulting in a print from a combination of coloured pigments, only without any visible boundary lines, thereby imitating mechanically the results obtained by the artist who blends one colour with another with his brush.

Anastatic Printing, in many respects analogous to lithography, had for its object, when introduced, the reproduction of fac-similes of rare prints, books, or portions of books, without necessitating the recomposition of such works. It is also applicable to the copying of manuscripts, as in the lithographic process. It was introduced into this country from Germany, by Mr. C. W. Siemens, in 1845, and was the invention of Mr. Baldermus, of Berlin, who forwarded a fac-simile of four pages of the 'Athenæum,' of the 25th of September, 1841, to the editor of that work early in October of that year, though the means by which the copy had been made was kept as a profound secret. The process is based upon the facts, that water readily combines with water, and oil with oil, that oil can be more easily spread over the surface of metal plates than water, and that metal may be readily moistened with a weak solution of gum, an operation which is greatly facilitated by the use of phosphatic acid. A knowledge of this led to the perfecting of the anastatic process, in the use of which the paper to be copied is first wetted with dilute nitric acid, passed through a press, and ultimately brought into contact with a plate of polished zinc. The acid taken up by the plain portions of the paper, etches or bites away those portions of the metal with which it is brought into contact, leaving a reversed copy of the letterpress in slight relief upon the zinc plate. The zinc plate is then washed with a solution of gum in weak phosphatic acid, which is readily attracted by those portions that have been eaten out by the nitric acid, but repelled by the grease set off upon the polished zinc, from the surface, whether from type, wood block, engraving, or manuscript. The zinc plate is then inked by means of an ordinary lithographic inking roller, and printed from in the usual way. Such are a few of the processes employed in the production of printing surfaces, but all, with the exception of the last named, have involved in their production, the skill of the artist, draughtsman, or engraver, and have yielded their prints upon paper or woven fabrics only, though recently the attempt has been made to print upon wood from metal types for the ornamentation of furniture, and the enrichment of internal architectural decorations.

The series of processes next to be considered are entirely distinct from the foregoing, and have been applied in copying natural objects mechanically, or in the reproduction of the drawings of the artist without the intervention of the engraver.

Nature Printing.—Many attempts have been made to copy and multiply natural objects mechanically by printing processes, but the book of art, by Alexis Pedemontamis, translated into German by Weeker, and bearing date 1572, probably gives the earliest hints as to taking impressions from plants. In 1650, Welkenstein, a Dane, gave instructions in the art. His method was to blacken in the smoke of a candle or oil lamp the object to be printed, and after it had been laid flat and dried, it was placed between two sheets of soft paper, and a rough impression of the veins, &c., of the leaves was thus obtained. In 1748, Seligman, an engraver of Nuremberg, published a series of plates representing leaves, which he had reduced to skeletons; but probably the most elaborate work illustrated by this method was the 'Herbarium Vivinum,' published by Kinhof, at Erfurt. The work was in twelve volumes, contained 1200 illustrations, and was issued between 1757 and 1764. In more recent times, the leaves of plants and other similar objects, in an undried state, were inked with printing ink, by placing them between sheets of blackened paper, and pressing them with an even gentle pressure, when the ink adhered to the more prominent portions of the surfaces; or by dabbing printing ink evenly over their surfaces, after which they were placed between sheets of clean paper, and pressed so as to obtain a print by the set off of the ink. Nature printing, as now practised, is altogether distinct, both as to its object and application, from any of the foregoing methods. It is asserted by Professor Thüle, that Peter Kyle, a Danish goldsmith, was the first to discover a method of impressing flat objects into plates of metal by passing them between steel rollers, but if so, the system did not come into use.

In 1847, Dr. Ferguson Branson, of Sheffield, proposed and applied the art of electroplating to the production of copper plates, obtained from moulds or impressions of natural objects pressed into guttapercha. Fromt he mould so procured he also took casts in brass. In 1851, the idea had taken hold of men's minds, that it was possible to get from natural objects metal plates from which to print. The first examples were however not so obtained, but were printed from wood blocks. The object to be copied was laid between two blocks of boxwood, which had been softened by steaming, and placed under pressure, so that it became embedded in the surfaces of the blocks, which were then dried. The piece of lace, or whatever it was, was then withdrawn, and by inking the surface of the block in the ordinary manner, an impression of white upon a black or blue ground was obtained. Nature printing was, however, doubtless brought to its present high state of perfection in Austria, in 1852, when impressions were taken from natural objects in metal plates, by means of rolling pressure. The secret had now been found out, that any object, however delicate, could be impressed into the surface of steel, if desired, by means of rolling pressure, without crushing the object so embedded, although an infinitely smaller amount would crush the same object, if flat pressure were applied. This principle was soon extensively applied at the Imperial printing office at Vienna, in copying ferns, leaves, plants, and flowers, but the desire had now been created to copy other classes of natural objects, such as agates, and other quartzose minerals. This was effected by the discovery of Professor Leydolt, of the Imperial Polytechnic Institution of Vienna, that it was possible to decompose the surfaces of such substances by means of fluoric acid, and that such decomposition could be so effected, as to admit of their markings and striæ being printed from casts subsequently taken, from which electro-deposited plates were obtained, which yielded prints at the copperplate printing press. The process was, however, carried still further at Vienna, for casts were made from objects such as fossils, which would neither bear pressure nor admitted of being acted upon by acids, and electro-deposited copper plates were thus obtained, which, in their turn, yielded the desired prints. The Austrian methods of copying natural objects was subsequently introduced and applied in England by the late Mr. Henry Bradbury. It must not be supposed from what has been stated, that steel was the metal employed for embedding the object sought to be copied, for, although such was possible, it was found desirable to use a softer metal, and Mr. Bradbury, in the production of his moulds, used either lead or guttapercha, from which the copper plates were obtained by electro deposition. While nature printing was being thus applied, both abroad and at home, in copying natural objects, in England new directions were given to the use of the principle of embedding substances in ornamenting the surface of metal articles of Birmingham manufacture, and this is stated by Mr. Aitken to be due to R. T. Sturge, of Birmingham. In the early attempt to ornament metal surfaces by printing other bodies upon such surfaces, it was imagined that, the harder the material out of which the pattern or design was made, the better it would be for the purpose, but such did not prove to be the case. "Who," asks Mr. Aitken, "could have predicted that so tender and fragile a fabric as ordinary thread lace would have sustained a pressure of not less than ten tons, and come out from such pressure comparatively uninjured, leaving its impression even on so soft a substance as Britannia metal; but how much greater is our wonder increased, when we find the same result produced on copper and on the harder metal, formed by its alloy with zinc, viz. brass, the yet harder German silver, iron or tin plate, and more wonderful still, on what we are led to believe is the most dense and hardest metal in ordinary use, viz. steel." The more perfect and closely twisted the thread of which the lace was made, the better and more definite was the impression. The transition from lace to paper was a natural one, and patterns or designs formed out of perforated paper were next tried; and he adds: "I have myself passed through metal rolls, without injury, the same piece of perforated paper (ordinary writing paper) not less than ten times, after which it was not entirely useless, but it became hard and brittle, owing to the cohesion of the particles being destroyed by the compression it had undergone." The purpose to which the last-named system of printing was applied was that of ornamenting Britannia-metal salvers, trays, and such-like articles. The perforated paper pattern was placed between two plates of metal, which were then passed through the rolling press. When the two metal surfaces were brought into contact through the perforations, they burnished each other, and, where the paper prevented such contact, an image of the grain or pulp of the paper was indented. Upon separating the plates and removing the paper pattern, the design appeared as a bright burnished pattern upon a frosted ground. The engraver or chaser was then called in to give form to the vessel, and outline to the pattern. Such was the simple and rapid method of ornamenting or printing metal work, employed at Birmingham, and one of the important commercial results which grew out of nature printing; but invention had not yet exhausted itself, for other persons than those already alluded to, were investigating and seeking to impress in metal the conceptions of the artist, without the intervention of the engraver. In order to attain this result, it was necessary that the artist should make his drawing upon a substance which would not absorb the fluid employed, and was incapable of impressing its own image, as did paper. The drawing, moreover, required, when dry, to be sufficiently in relief to make an indentation capable of holding the printing ink. These objects were attained by Mr. George Wallis, who did not attempt to imitate engravings on copper or steel, nor the effects of wood engravings, but simply to reproduce in metal plates such effects as can be easily obtained in ordinary drawings done with a pen or a pen and brush, in a single pigment. His drawings were executed in a variety of substances, but always with an ink which crystallized upon the surface of the substance on which it was used. The most successful examples of this process resulted from drawings made on sheet gelatine, in which, in addition to the lines produced by drawing with a pen or the brush point, broad washes were introduced, giving an effect somewhat similar to aquatint, but more free and less mechanical. The drawings were then embedded in plates, principally of white metal, and when covered with a deposit of steel, by means of the acierage process, a considerable number of impressions and several plates could be produced from the same drawing. A special machine for impressing the plates was an essential part of this invention, and as extreme accuracy in the application of the force employed, according to the thickness of the plate and sheet gelatine, was essential, the action of the machine constructed for the purpose by Mr. Whitworth could be regulated to the 1520th part of an inch. The attempt thus made to reproduce a facsimile of the artist's drawing has not however become commercially successful, and other attempts have since been made to effect the same object, the most recent being the

Graphotype Process, which has for its object the production of metal blocks in relief, direct from the artist's drawing, and capable of being worked in the type form at the printing machine. This is effected by making the drawing upon a slab of compressed chalk powder, the surface of which is first coated with a thin film of size. The drawing is then made with a composition of glue and carbon, and as soon as the latter is dry and hard, the size which covers those portions of the slab unprotected by the lines of the drawing, is removed by means of pumice-stone powder; the particles of chalk are thus set free, and can be brushed out, and the drawing then appears in relief.

It is next covered with a piece of tissue paper, upon which a soluble silicate is poured, and through which it is absorbed by the chalk slab, the drawing being thus converted into a hard, stony substance, from which plaster casts are taken, which in their turn yield the usual type-metal blocks. This process possesses great capabilities, but, like lithography and many other processes, requires that artists should be trained to a special manipulative skill in the use of the materials, if satisfactory results are to be obtained from the blocks produced. Many of the examples issued fail to give satisfaction, just in proportion as the draughtsman attempts to imitate some previously existing style. Each new process introduced possesses powers and fitnesses of its own, and just as those powers are skilfully applied, so is the result satisfactory. There is a common error into which the majority of inventors fall; viz. that of attempting to imitate what has previously been done, rather than to work out and perfect that which their own process is able to effect. As constant reference has been made to the production of copper plates by means of the electrotype process, and as other processes have still to be referred to, it may be well to describe that one in as few words as possible.

The art of depositing metal upon any desired surface is due to the discovery, in 1800, by Volta, of the galvanic pile, and this was followed by the invention of the galvanic battery by Cruikshank, and by the observations of Wollaston in 1801, that if a piece of silver in connection with a positive metal, was put into a solution of copper, the silver became coated with copper. Spencer, in 1837, discovered that if a portion of the surface of a negative plate was varnished, the deposits of metal took place only on the unvarnished parts, and this led him to conceive the idea of coating a piece of copper with varnish and wax, and of cutting a design through it, so as to leave the copper bare, to admit of a deposit of copper in the lines, thereby producing the design in relief. Professor Jacobi made a similar discovery about the same period, and Mr. Jordan also published his discovery in the same year. Mr. Robert Murray next found, that if the surfaces of plaster casts and similar non-conducting bodies were coated with plumbago, it was no longer necessary to employ metallic plates or moulds in order to obtain metallic deposits. To these facts the processes known as electrotint, glyphography, etching by galvanism, etched daguerreotypes, photo-galvanography, the acierage process, Vial's instantaneous engraving, and some of the photo-electric relief block processes, owe their creation.

Electrotints are prints from copper plates, obtained by depositing copper upon the surface of a design modelled in wax or composition.

Acierage is a process, by means of which an iron face is deposited upon the surface of an engraved copper plate by the action of the battery, thereby obtaining greater durability, without injury to the artistic character of the work as originally produced.

Vial's instantaneous engraving depends upon metallic precipitation, and the relative affinity of acids for different metals. The engraved plate is obtained by making a drawing upon the polished surface of a steel plate with a greasy crayon, or any other substance capable of resisting a deposit of copper, without opposing the corrosive action of acid, when the plate is immersed in an acid bath of sulphate of copper. Upon immersion the bright surface of the plate immediately becomes coated with copper, but the acid of the bath gradually corrodes and undermines those portions of the plate, the surface of which is protected by the greasy drawing, eating it into a series of lines, from which the print is produced by the ordinary process of copper-plate printing. This process is employed for the outline designs used by potters, the design being printed and transferred to the surfaces of plates and other articles, which are then filled in and coloured by hand.

Glyphographs are blocks obtained by coating a plate of metal, or other substance reduced to an uniformly flat surface, with wax or composition. The design is then made upon the surface of the composition, which in its turn is removed, wherever it is wished to obtain a metallic deposit. The metal block, when obtained, is mounted on a wooden back, and is then capable of being printed from with type in the ordinary printing press. It may be stated, that the method employed in printing from incised surfaces in greasy inks is effected by forcing the ink by a pad into the lines, the excess of ink on the surface of the plate being subsequently wiped off by the printer with a loose canvas. The skill of the printer consists in so arranging the direction in which he wipes off the ink, as to avoid drawing it out of the lines. After the excess of ink has been removed, the surface of the plate is further cleaned by wiping it with a piece of soft muslin, and finally the oil running on the surface of the metal plate is taken off by a little whiting applied on the palm of the hand. The plate thus prepared is placed on the bed of the press, so as to bring the paper into intimate contact with the surface of the plate and the ink in the lines of the plate, the upper roller of the press being covered with a series of blankets to prevent cutting or crushing. The paper, when removed from the plate, draws with it the ink from the lines of the engraving. In printing from raised surfaces, the reverse action takes place, the design being in relief, and the ink being put on evenly by a roller over the entire surface, after which the paper is applied, the press used, and the desired print obtained.

COTTON PRINTING.

The colours printed on silk and wool are well known to be more brilliant than those produced on cotton or linen, and the object aimed at in the preparation of cotton for printing is not merely to give it peculiarity of surface, but also the capability of taking the brightest as well as the most durable printed designs. The art of cotton printing was known in India long prior to its introduction into Europe, and as practised in Sindh, depends mainly upon the use of mordants and resists.

Printing by discharges is but little known or practised in India, as it requires an amount of chemical knowledge, which is not at present possessed by the natives of that country.

As a necessary result of this want, the cotton prints of India seldom consist of any but the more positive colours, half tints such as pinks, drabs, olives, &c., so valuable to the English calico printer, being rarely met with.

In England, all large printworks embrace bleach, dye, and printing works, as the plain cotton cloth intended for printing upon requires to be freed from extraneous substances used in the manufacture and preparation of the cloth itself.

Printing on cotton previous to 1715 was effected by means of wood blocks, and about that date engraved metal plates were applied, though since that time, however, cotton printing has undergone most important changes, owing to the introduction and use of engraved cylinders. The production of designs for the use of the cotton printer forms an extensive and important industry, their character varying with the markets in which the goods are to be sold. South America demands prints of the most brilliant colours that can be produced, whilst the home markets require varied goods.

Printing on cotton and other fabrics was formerly effected by means of wood blocks and metal types, either separately or in combination with strips of wood or metal, according to the nature of the design. Engraved metal plates were also employed, but each and all of the processes were slow and intermittent, and ultimately led to the introduction of cylinder machines, a patent for which was granted in 1764 to Thomas Fryer, Thomas Greenough, and John Newbury. The patent was for a machine of a new construction, and for mixing and adapting colours to the use of the said machine for printing, staining, and colouring of silks, stuffs, linens, cottons, leather, and paper by means of engraved copper cylinders, on which the colours were laid by smaller cylinders put in motion by other plain cylinders, and the whole work of filling in, clearing off, and stamping the impressions was performed. The machine was worked by horse, water, or wind power, and "the colours and stains made use of were extracted from different dyeing drugs, fixed by the help of oil of vitriol, aquafortis, aqua regis, spirits of salts, alum, cream of tartar, sal ammoniac, volatile and fixed alkalies, and quicklime, used in various proportions as the shade of colour is required lighter or darker."

In 1772 another patent was granted to "Joseph Adkin and his son, Charles Taylor, and Thomas Walker for a press in which three cylinders working vertically were employed, the printing cylinder being 3 inches in diameter, and capable of printing a fabric 22 inches in width." When striped patterns only were required to be printed, previous to the use of engraved cylinders, strips of copper were screwed into a frame with blocks of wood, which served to space out the distance at which the stripes were to be repeated, as well as to steady and support the copper strips themselves, but by this arrangement one colour only could be printed. An improvement in the block was subsequently introduced, in which one series of copper strips was made to rise and fall between those on either side of it, the strips being projected or withdrawn from the face of the block, as required, by means of a screw, by which arrangement the block admitted of being coloured from two sieves with distinct colours, which were printed simultaneously. Stripes so printed were sometimes combined with figured patterns, in which case the pattern was printed from a separate series of blocks, formed by fixing the requisite number of blocks on boards in their required position by screws, nuts being placed upon the screws on either side of the blocks to support and retain them at proper intervals. A hard wood face was then attached to the boards on blocks, upon which the design was engraved in relief. When engraved copper plates were introduced as the means of printing, the design, instead of being cut in relief, was sunk into the surface of the plate, and the plates, so prepared, admitted in some cases of being used so as to print one or more colours at one operation. This process was, however, slow, and the number of impressions limited, owing to the wear of the copper plates; and copper cylinders of about 5 inches in diameter, and from 30 to 40 inches in length, with the designs engraved on their surfaces, were ultimately substituted for plates. Both cylinders and plates were engraved by the process of line engraving, already described, but the chalk, aquatint and other processes were also occasionally used. Cylinders so prepared were employed until 1808, when Mr. Joseph Locket adapted and applied the process of repeating designs, introduced by Mr. Perkins, and known as

Siderographic Engraving.—This process was introduced for securing perfect identity in the reproduction of bank notes, and as a means of increasing indefinitely the product from a steel plate, when once engraved. This was effected by hardening and tempering the original engraved steel plate, and then pressing into the lines of the engraving the surface of a soft steel cylinder, by means of rolling pressure from a hydraulic press. The cylinder, so embossed, in its turn was hardened and tempered, and its embossed face rolled over and indented into the surface of a soft steel plate. Mr. Locket adapted this system to the impressing of designs on copper cylinders for the use of the calico printer.

The engraving of cylinders for calico printing has since undergone many changes, and not only have the engravings acquired sharper outlines and finer details, but the methods of engraving have been greatly multiplied. The pentagraph has been applied, by which designs could be copied, enlarged, or diminished as desired, and any number of repeats of the design etched on the cylinder. Excentric engraving has been extensively used as the groundwork of prints, or as they are termed "covers," and galvanism has been called in to aid the diamond tracer in etching any desired pattern upon the copper cylinder.

The pattern is traced with varnish on a zinc cylinder, so placed in the engraving machine, that as a needle passes over its surface and comes into contact with the zinc, a galvanic current is established, and by simple machinery causes the diamond to trace the corresponding pattern on the copper roller. The process is so rapid and precise, that rollers of 43 inches in circumference and 44 inches long have now been introduced, enabling the calico printer to produce cheaply large furniture patterns. When, however, the system of printing from copper cylinders was introduced, it was not long before several cylinders were employed at one and the same time, the cotton passing as an endless web between the cylinders and a drum, each cylinder printing its portion of the design in rapid succession. Calico printing thenceforward became a continuous and economic process, resulting in but little wear to the cylinders themselves, as they were filled with, and cleared of the superfluous colours mechanically and as rapidly as the machinery could be made to give motion to the cylinders, which soon attained to a speed equal to the production of one piece of printed cotton per minute. The style and fashion of printed calicoes have not unfrequently had their origin in the improvements which have been made, or economy effected in the production of the cylinders.

Till within a comparatively recent date, coloured designs printed on woven fabrics by means of either blocks, plates, or cylinders were the combined result of the use of colours, mordants, discharges, and resists. Mordants were used to combine the colouring substances permanently with the fabrics, discharges to produce an exactly reverse effect by driving off portions of the colour after printing, whilst resists were printed into such portions of the fabrics, as it was desired to keep entirely free from the influence of colour under any of the foregoing varying conditions.

Cotton printing was not a merely mechanical process, but an art which required a considerable amount of chemical knowledge to enable any given design to be reproduced; many of the old processes have now been superseded. The red colouring matter obtained from madder may still, however, be considered as one of the most important used by calico printers, on account of the variety of shades that are obtained from it by the use of proper mordants, one dyeing operation being sufficient to produce pinks, reds, purples, violets, and blacks; notwithstanding that alizarine (according to Dr. Schunck) is the only colour-giving principle of madder. The following colouring substances used by the calico printer may also be enumerated:

Garancine, munjeet, campechy or logwood, peachwood, sapan-wood, lima-wood, sandal-wood, camwood or barwood, safflower, cochineal, kermes, gumlac, murexide or Roman purple, indigo, orchil, cudbear, litmus, Prussian blue, ultramarine, quercitron, fustic, Persian berries, weld, aloes, turmeric, annatto, ilexanthine, lo-kao, tannic acid, gallic acid, sumach, valonia, divi-divi, myrobalans, catechu, gambier, and gumkino.

After the perfecting of the cylinder printing machine, probably the most important improvements ever effected in the dyer's and printer's arts are due to the discovery of a series of aniline or coal-tar colours. Coal-tar colours, when first applied to the art of the calico printer, were merely mixed with gum and albumen, printed upon the goods and steamed, by which means the albumen was rendered insoluble, and the colours thus fixed mechanically. Several other plans were subsequently tried, but the process ultimately and almost universally employed was discovered by Alexander Schultz and Mr. Perkins, and consists in printing the colouring matter with a mordant, composed of a solution of arseniate of alumina in acetate of alumina. On steaming the cloth thus printed, the colour is found to be fixed in the fibre, and the goods are then soaked and finished. One of the great advantages of this process is, that it can be worked in patterns consisting of a great number of colours, and is also suitable to nearly all the anilines, which now range throughout the entire spectrum.

Messrs. Brooke, Simpson, and Spiller are the proprietors of Mr. Perkins' as well as of Messrs. Maul and Nicholson's works, in the latter of which all the discoveries by Hoffman and Nicholson were commonly applied. The former works belonged to the first producer of aniline as a dye, and also the discoverer and manufacturer of artificial alizarine; the last, a most important point in connection with calico printing and dyeing.

Artificial Alizarine.—Mr. Perkins, in a paper read by him before the Chemical Society, in May, 1870, recites in detail the results obtained by the various investigators in Germany, as well as by himself, respecting the formation of artificial alizarine from anthracine, an hydro-carbon derived from coal tar; and finding that MM. Caro, Græbe, and Leiberman, in

Germany, were carrying on similar investigations, and had obtained analogous results, they have agreed to work together in future. He says: "The colouring matter obtained either by Græbe and Leiberman's process, or from the sulpho-acid anthraquinone, I have invariably called alizarine." The identity of this substance with the alizarine of madder has however been called in question, but having compared the two with every well-defined reaction of alizarine, he finds and believes them to be in all respects identical. Recent investigation has therefore proved to a great extent the truth of Dr. Schunck's remarks, that the final result of dyeing or printing with madder is simply the combination of alizarine with the various mordants employed. As a result of the discovery and introduction of the aniline colours, the prints and dresses worn by ladies were for a time more pure and brilliant in their hues than from any previously employed. The discovery of artificial alizarine has now caused a return to the use of more sombre colours, similar in their nature, and alike durable with the madder dye of the past.

It will be readily understood that it is necessary that the mordants or colours to be printed should be of sufficient consistency to remain on the fabrics when delivered from the cylinders, so as to produce sharply defined patterns; and as a great variety of chemical products is employed, an equal variety of thickeners becomes also necessary. Thus flour, starch, farina, various natural gums, albumen, lactarine, gluten, and several preparations of flour and starch called calcined farina, and patent gums, are used for this purpose.

The exports of printed goods from Great Britain in 1851 amounted to a total of 15,544,000 pieces, and have since greatly exceeded that amount.

Printed Paper Hangings.—This industry probably had its origin in the desire to find an economic substitute for the embossed, coloured, gilded leather and tapestries formerly used in the castles and palaces of the wealthy. That such was the case there can be little doubt, for paper in its turn was printed to imitate striped and flowered silks, marbles, porphyry, embossed woollen cloths, and gilded and silvered fabrics. It is not improbable that the art of printing paper hangings by means of wood blocks was brought into England by French refugees, between 1620 and 1630. Several descriptions are now manufactured, but the origin of the industry is somewhat uncertain. They were originally printed from wood blocks or engraved copper plates. It was usual, after the excise duty had been stamped upon each sheet, to paste the sheets together in lengths of twelve yards, after which it was ground-coloured and printed upon. The paper is now manufactured in pieces of any required length or width, and is printed upon by means of cylinder machinery, after which it is cut into lengths of twelve yards for sale. The most modern style of paper decoration is that in which the designs are printed on a thick-bodied paper, in imitation of old leather hangings. The higher or best class of paper hangings is still made by hand, the design being printed on either plain or coloured grounds by wood blocks, the effect being generally dependent upon the number of blocks used. In France it is still the practice of some makers to touch in portions of the colours by hand, in which industry many females are employed. Satin papers are printed like plain papers, but the surface is first prepared by working powdered steatite uniformly over it. The preparation of satin surfaces is emphatically a work of skilled labour. In the case of flock paper, the pattern or design is blocked into the paper in strong size, and the flock or ground wool waste of the desired colour is then spread over the entire surface, the loose or unattached portions being removed when the size has set. When the flock design is required to be left in high relief, as in the case where such papers are to be painted upon to diaper or otherwise ornament the walls, in imitation of tile patterns, to produce Alhambra effects, the paper is double blocked, or blocked with size a second time upon the first or single flock, and a second coating of flock is then attached.

The paper stainers' trade affords a singular illustration of the effects sometimes resulting from strikes and trade unions. About thirty-five years ago all paper hangings were printed, each colour from a single block and by a separate operation, but after that period the cotton spinners of Manchester had applied cylinder machines to the printing of cotton piece goods, and attempted to do the same for paper hangings. The hand-block masters of London, to meet the anticipated Manchester competition, proposed to use an enlarged block, to print several colours at the same time, and to work blocks by means of levers and not by hand. The workmen would not hear of the use of machinery, but struck, starved, attempted to arrange, starved a little longer, and ultimately expelled the lever block, to come back and work at hand blocks double the former size and weight, thereby necessitating the enlargement of the colouring sieves, which then admitted of being patched with several colours. Such was the origin of patching the sieve with several colours, the practice now generally employed in printing cheap blocked papers, and by means of which several colours are printed simultaneously on separate parts of the surface of the paper.

A large proportion of the wall papers now used are, as in the case of cotton goods, printed by means of cylinder machines, in some cases as many as twenty colours being required to be printed in succession. This is effected by arranging the requisite number of engraved wooden rollers with their colour troughs and felts upon the outer diameter of the drum of the machine. The rollers or printing surfaces, being in high relief, receive and deliver their respective colours alternately at each revolution of the machine, the print being impressed upon a continuous web of paper, carried forward from the printing cylinders into a hot-air trunk to harden the colours, which are thickened with animal size. The cylinder machines at present in use are stated to be capable of printing from 1000 to 1500 pieces per day.

Carpet Printing.—Printed carpets are a comparatively recent product of manufacture. The carpets and tapestries of ancient and mediæval times were rather the product of the needle than of the loom, and the preparation and carding of the wool was performed by slaves.

According to Pliny, thick flocky wool has been esteemed for the manufacture of carpets from the remotest ages, and the shuttle appears to have been early used in combination with the needle. Eastern empires have at all times maintained the well acquired celebrity of their carpets, and India, Persia, and Turkey carpets have a world-wide fame at the present time.

It is impossible to enter here upon a detailed account of the various processes of manufacture employed in the East, on the Continent, or even at our own great seats of the carpet industry. The manufacture of Brussels carpets was first introduced into Kidderminster about 1735. In 1838, it employed about 1765 Brussels hand-looms, and in 1851 about 2000, and the industry had spread into other districts, including Halifax, Durham, Kilmarnock, &c. The power loom was not largely and successfully applied in this industry till about 1855, and it is hoped that by increasing our power of production, and by the process above described, and at the same time reducing the cost of the product to the consumer, the manufacturers of this country may be enabled to compete successfully with the foreign producers of carpets in American and other markets.

It is to two classes of carpets only that it is necessary to refer, viz. those woven by the power loom, and known as tapestry carpets, and printed pile *carpets.* Tapestry carpets are similar in fabric to the ordinary Brussels carpets, the pattern of the latter resulting from the use of the Jacquard loom, while the cloth or fabric of the tapestry carpet is woven in the power loom in a similar manner to any plain wool-pile fabric, attempts to print upon which had not been successful. Mr. Richard Whytock conceived the idea of printing upon the wool threads of which the carpet was to be woven, the various colours necessary to produce the design, when gathered up by the loom, and thereby save the coloured wools thrown into the back of the carpet in the old process of weaving. If a piece of calico bearing a handsome and complicated pattern is taken and the threads are pulled out, the design on the cloth will be found to result from an ever varying series of bars of colour, and the whole pattern may be resolved into a number of variously barred threads. The problem which Mr. Whytock solved was, how to convert a series of printed barred threads into a pattern, in order to produce a Brussels pattern with but one layer of coloured worsteds. He at length succeeded in determining the relative quantities of each succeeding bar of colour necessary to be printed, to permit the amount of coloured thread lost in forming the loop or pile being taken up, and he had then only to arrange the printed warp in the loom and weave the carpet, as if it were a piece of plain pile fabric, the gathering up of the pile resulting in a combination of the bars of colour into the desired and prearranged design.

Printing upon woven carpets was effected by Mr. Joseph Burch, and his productions were known as printed pile carpets. In printing carpets, mordants, resists, or discharges are employed as in calico printing. Before the colour is applied, it is mordanted by passing it through a weak solution of sulpho-muriate of tin, and afterwards through chlorine and dilute sulphuric acid. This was necessary, in order to fix topical colours upon the fibre, which having been well saturated with the mordant, became the medium of their chemical combination; and this being done, the carpet was washed without removing the mordant, and the excess of water taken away by centrifugal action. In order to print upon plain velvet pile or terry goods, it is necessary not only to print the surface or end of the pile, but to cover the whole depth of it with colour; the apparatus by which this was effected consisted of a series of block-printing machines firmly joined together at equal distances, by connecting shafts and gearings, so that the whole of the various parts of the machine being brought into action, each block prints its respective portion of the design on the same piece of carpet simultaneously. The carpet to be printed was made to enter at one end of the machine, and was carried forward between the intervals of each impression through a distance equal to the exact length of the design. But in printing, two, three, or four repetitions of the block impressions are necessary in order to colour or stain the pile to its foundation. The force and pressure of the blocks upon the pile could be varied at pleasure, the colour in the first blocking being well forced into the pile, while the last applied the colour lightly on the surface only, to ensure a more brilliant effect in the finish.

Floorcloths, as now used, are of several descriptions, but, as originally applied, had reference to one description of material only, viz. that which consists of a cloth or canvas which has been coated with linseed oil on both sides, the under side being left plain, whilst the upper surface was ornamented with some design or pattern, usually printed into it by means of blocks. The cloth now used as a foundation for oilcloths is made from flax, tow, or yarn of a coarse quality, a rough and fibrous surface being best adapted for taking on and retaining the paint. The cloth is made in immense webs, measuring 350 yards in length, and 8 yards in breadth, and the looms required to weave it are consequently of gigantic size. When this cloth was woven by hand, two men were required to work each loom, and the weaving of a web 150 yards long occupied them for about fourteen days. The power loom has, however, of late years been introduced, and Messrs. Nairn were the first to employ it. When the weaving is completed, the web is cut up into fourteen "cloths," each 25 yards in length. The "cloths" are taken to the frame-room, and stretched firmly on vertical frameworks of wood, and in that position are sized and painted. The "back," or what is to be the lower side of the fabric, is first operated upon, and after the two coats of size and paint which are bestowed on it have been thoroughly dried by the admission of hot-air into the apartment, the cloth is turned, and the "face" is subjected to a succession of sizings and paintings. The paint is mixed of the consistency of treacle, and the pigments used are chiefly ochres and leads, each cloth requiring about half a ton of paint to face and finish it. The size is applied by a broad flat brush, after which it is dried, and the surface sheared so as to fit it to receive the paint. The latter is spread evenly by trowels, again dried and reduced with pumice-stone, and these operations are repeated until the required body and surface are obtained.

At present a great variety of designs is printed on fabrics of this class, the designs being made like the patterns of Berlin woolwork. They are printed by hand from wood blocks about 18 inches square, varying in number with the coloured designs. The blocks used in printing the outline of the pattern have the figures formed on their surface either in copper or type metal, and sometimes in a combination of both. The "filling" blocks are faced with boxwood, and before being "cut," the printing surface is sawn into minute squares—81 to the square inch—the saw penetrating to a depth of nearly a quarter of an inch. These squares correspond to the squares in the design, and the block is prepared by all the squares being chipped out, except those that are required for the colour to be printed. The division into squares has another and more important purpose. If a close surface were used, the block would not take up or lay down the paint evenly or in a sufficient quantity, and it would squeeze out at the edges of the figures, owing to the necessary thickness of the colours. In some cases where large masses of colour form part of the design, the outline of these portions only is printed, and the colour is filled in by hand. The blocks are inked, or more properly painted, by pressing their surfaces upon cushions, upon which the requisite colour has been carefully spread: and having been thus charged, the cloth is gradually unrolled upon a table, and the block colours are applied in succession, each block, when brought into contact with the surface of the cloth, being struck with a heavy mallet, in order to cause perfect contact over its entire surface, and the colour to be drawn off the block into the cloth. Any imperfections in the printing are corrected by colour applied by hand.

The method above described was the only one employed in the manufacture of floorcloths for many years; but in 1844 Elijah Galloway invented a method of combining indiarubber with a large amount of cork, and then rolling it into a substance about $\frac{1}{8}$ or $\frac{1}{16}$ of an inch thick, which may be printed with an oil paint by means of the ordinary floorcloth printing blocks. The material was called kamptulicon, and has increased in public favour so much, that its manufacture now forms a considerable industry. It is noiseless when trod upon, and much warmer to the feet than ordinary floorcloth, and has been largely adopted in churches, banks, libraries, and places where quietness is desirable.

As the process by means of which cork and indiarubber were rendered capable of being combined, is peculiar, and not generally known, it may be stated that to the schoolboy of former days we must ascribe the discovery of a process by which this might be accomplished, viz. that the continued mastication of a piece of indiarubber rendered it soft and plastic, and a similar result is obtained by the use of machines called masticators, which were invented to overcome the great cohesive power of indiarubber. These machines consist of a cylinder of cast iron, mounted on a suitable frame; a central shaft armed with coarse teeth revolves in it, and there is a grated door in front to fill and empty it. When indiarubber is put into the cylinder, the revolving shaft gives it motion, and by continual mastication by these powerful teeth, aided by the heat with which the enormous friction is attended, it is speedily reduced to an uniform homogeneous mass. Water is admitted into the cylinders to wash out any impurities in the rubber. It is then transferred to a dry masticator, and there worked until all the moisture it contains is completely evaporated. Well-made rollers next spread it into thin sheets like paper, or it may be dissolved into "varnish;" or the more solid "dough," as it is called, may be digested with more or less naphtha, aided by mechanical friction, a very short time being necessary to do this, after the structure of the indiarubber is so thoroughly altered.

Numberless attempts have been made to produce artificially a material possessing the properties of indiarubber, but they were attended with but little success, till Mr. Frederick Walton, in 1860, discovered his method of treating oxidized oil, whilst engaged in attempts to manufacture artificial leather. He thus describes his discovery: "Having accumulated a quantity of solid oxidized oil by drying it upon extensive surfaces of any kind, such as prepared cloth stretched in frames, I then scraped or peeled it off by suitable means. At first my attention was solely directed to the attainment of a speedily drying flexible varnish at a moderate temperature, but very few experiments with this oxidized oil led me to notice its rubber-like qualities, which I at once conceived might, with further manipulation, and with some combinations, be developed more fully, and become a valuable substitute for that article. Encouraged by success at every step, I proceeded, and soon found that by crushing the solid oxidized oil obtained in sheets, and working it thoroughly in hot mixing rolls, I produced a substance which required only the cohesive nature of india-rubber. The addition of a small quantity of shell-lac soon gave that which was wanting, and I found in my possession a material singularly like caoutchouc when worked into dough, and which could be rolled on to fabrics in the same manner and with the same facility, giving a perfect waterproof cloth not unlike oilcloth, but having the rubber finish and flexibility. Pigments could easily be added to give colour; the addition of resins gave other or rather varied proportions of adhesion useful as affording the means of uniting fabrics, as by rubber. Fibres, whether flock or cork, mixed with the oil and rolled into sheets, gave me samples of kamptulicon and other floorcloths." Oil thus treated and combined with cork is now extensively manufactured under the name of linoleum, which forms the third and last description of printed floorcloths now generally used. It is capable of a greater variety of tints in the ground colour than kamptulicon, resists the action of moisture and extreme variations of temperature better than indiarubber and cork, and dries more readily when washed. It is printed by the same process as is floorcloth and kamptulicon, and its manufacture now forms a new and important industry.

In drawing these notes upon printing as an industry to a close, it must be stated that engraved plates, wood blocks, lithography, and photography have all been employed in the ornamentation of pottery and glass; but the process most largely employed is that of engraved copper plates, the work upon which requires to be strong and somewhat coarse, if considered from an artistic point of view. The prints used in the ornamentation of pottery wares are taken on transfer paper, the inks or colours being composed of certain oxides of metals mixed with other substances to the consistency of treacle. The lines of the engraving having been charged with ink, the surplus is removed from the surface of the plate by a knife, and after it has been further cleaned, so as to leave the ink or colour in the lines only, the print is taken upon transfer paper by the common press, the paper having been first damped with soap and water. The print so obtained is placed with its face against the ware to be ornamented, and, being thus brought into close contact, the ink or colour is absorbed into the ware. The paper is then washed off, after which the ware is glazed and fired.

The process of printing directly on to the body of *the bisque* ware, which has been proposed, though it has not been applied to any large extent, is interesting. It consists in taking an engraved metal block, copies of which are made in any required number by electro deposition. The surfaces of the blocks must be flat or curved, according to the form of the article to be printed on. The ware to be printed is first moistened by a dilute acid solution, and the blocks are then brought into position and contact with the surface, and form part of an electric circuit. On causing a current of electricity to flow through the blocks, a minute quantity of the metal from the surface is deposited upon the ware, which upon firing appears as a design in colour, according to the nature of the metal used.

Printing on glass is among the latest attempts to transfer the image or design produced upon or in one surface to that of another. The most delicate are those obtained by the agency of photography, vitreous photographs, both on glass and enamel, being largely produced both in England and abroad in the present day, while for commercial purposes printing on glass is now effected by means of indiarubber.

Such then are a few among the multitude of processes which have been proposed for adoption in the production of prints. We have not yet arrived at what is desired, in order to permit of surface blocks being obtained from the artist's drawing direct and without skilled labour.

Those hitherto obtained have been deficient in amount of relief, and have consequently not admitted of being worked with the type in the steam press.

Photography is now lending its aid to artists, and much economy in the production of blocks is being effected by its agency, and it is probable, that if artists will so modify their style of drawing as to get rid of middle tints, at no distant date we may see much of our literature illustrated by its agency.

PHOTOGRAPHY.

By P. Le Neve Foster, M.A. (Society of Arts).

According to the last census (1871), there were 4715 persons in the United Kingdom directly engaged in the practice of photography; of these 4021 were males and 694 were females, and there were besides, seven makers of photographic apparatus—no small army of workers in an industry which dates only from 1839. In addition to these there must be taken into consideration the numerous trades and occupations that deal with the materials with which the photographer works, and these alone are legion. In the early part of 1839, Daguerre's discovery, that the fleeting images in the camera obscura could be fixed, startled the world, and the mysterious plates were handed about in scientific society with wonder and delight. To utilize the darkening action of light on chloride of silver had long been a dream among scientific men; and Wedgwood, Davy, and others, some years previously, had produced impressions on surfaces prepared with a silver salt, but had failed to fix the fleeting image when it arrived. Later on in the year 1839 the actual process by which Daguerre obtained his picture was revealed, the revelation having been delayed in order that a law might pass the French Chambers granting to Daguerre an annuity of 6000 francs, and to Isidore Nièpce one of

4000 francs, for their joint discovery. Shortly afterward Fox Talbot exhibited his photogenic drawings, followed by his grand invention of the Talbot-type, as it was termed, or, as he named it, Calotype. It is singular that Daguerre and Nièpce on the one hand, and Talbot on the other, should without concert with each other have employed a similar sensitive agent, though in a totally distinct direction. Daguerre formed a surface sensitive to light by exposing a silver plate or silvered surface to the fumes of iodine. Talbot effected his purpose by covering a sheet of paper with iodide of silver, rendered sensitive with a solution of nitrate of silver, acetic acid, and gallic acid. In each case the impression after exposure to the image in the camera obscura was invisible, and not a trace could be seen of any alteration on the surface of the plate or the paper. The latent image, as it is termed, had to be rendered visible by subsequent treatment. Here a considerable divergence takes place. In the case of Daguerre the latent image is brought out by exposing the plate to the fumes of mercury, the vapour attaching itself only to those portions of the plate which have been subjected to the influence of light. The action is of an analogous character to what takes place when a letter or drawing is traced on an ordinary looking-glass with a piece of French chalk, and the surface rubbed apparently clean. If this be breathed upon, the vapour condenses only on the untouched portion of the glass, and the traced figures are at once visible. Such is the action of the mercury vapour on Daguerre's plate.

In the case of Talbot's exposed sensitive paper, a totally different process is adopted for rendering the impressed image visible. The surface is washed with a solution of gallic acid, acetic acid, and nitrate of silver, when the image gradually reveals itself by darkening the paper wherever light has fallen, the darkening being in proportion to the amount of light in the image to which it has been subjected in the exposure in the camera. Here must be noted the difference between the two results. In the Daguerreotype we have the simple image shown by the white deposit of the fine globules of mercury, contrasted with the shadows shown by the plain polished silver surface, whilst in the case of the Talbot-type we get the image in a reversed condition; wherever the lights of the object have fallen, the paper is blackened, and whilst the darker portions exercising no influence on the sensitive surface are represented by the white or unchanged portions of the paper, we thus get what is termed "a negative." This at first sight might seem to be a disadvantage, but in reality it is a great advantage, and at once gave an admitted superiority, for many purposes, over the Daguerreotype, inasmuch as it enabled an unlimited multiplication of the true, or, as it is termed, the "positive" image to be effected in true gradations of force and shadows, and this by a very simple process. It was only needful to place the paper "negative" obtained as above, but rendered translucent by being waxed, over a piece of sensitive paper, pressing the two together under a sheet of glass, and exposing it in such a manner that the light passing through the negative fell on the sensitive paper, forming an impression or image in reversed and therefore true lights and shadows. Here, however, two points naturally arise requiring further explanation; for it will be asked how the Daguerreotype, still sensitive to light, could be preserved from destruction, or the sensitive paper of Talbot be subjected to its various manipulations, or be used for the multiplication of positive copies? The manipulations necessary for the production of the image on the Daguerreotype plate and the Talbot-type paper negative were carried on in the feeblest possible of lights, but it was soon found that these sensitive surfaces were not affected by a yellow or a red light, and henceforward the operations could be readily conducted in rooms or boxes with a window of yellow or ruby glass. Assuming, however, all these to have been duly effected, there was then the second difficulty, that of getting rid of the sensitiveness of the plate or paper without injuring the image, so as to enable it to be shown in daylight without destruction; or in the case of the Talbot-type negative, to admit of its use for the multiplication of positive copies. This puzzled those who had attempted photography in the earlier days, and in fact had stopped all progress. Various means had been adopted, such as washing the papers, to get rid of the sensitive chemicals, but this proved ineffectual; solutions of ammonia, common salt, bromide of potassium, and a variety of other materials, were subsequently tried, with more or less efficiency; but it was not until the discovery by Sir John Herschel that hyposulphite of soda would convert the unaffected silver salts into soluble matters, which could readily be washed away, that a satisfactory result was obtained. The Daguerreotype plate and the paper negative or positive, as the case may be, were placed in a tolerably strong solution of the hyposulphite of soda, and afterwards well washed and dried. They thus became no longer sensitive, and could be exposed to the light with impunity.

The multiplication of positives from the negative is technically termed "printing," and the "prints" are taken on a sensitive paper of a simpler character than that described as above for use in the camera; the print appears at once on it, and not as a latent image, requiring development as the negative did. A sheet of paper is floated, with its surface downwards, on a weak solution of common salt, chloride of ammonia, barium, or other chloride, and then hung up to dry; when dry, this is similarly floated on a somewhat strong solution of nitrate of silver, and thus, by chemical reaction, a surface of chloride of silver is formed on the paper. This chloride blackens when exposed to light, and thus when exposed under the negative, as referred to above, the positive image, in tones and gradations of black and white proportionate to the action of the light modified through the varying densities of the negative image, is obtained. Various means have been tried to give a smooth surface to the paper, so as to get greater perfection in the delicate details of the negative, and this has been accomplished by giving the paper a surface of albumen, obtained by floating it on a more or less dilute solution of albumen, with which is mixed any of the chlorides above named, according to the fancy of the albumenizer or the wishes of the operator.

When, however, prints thus obtained, whether on the plain or albumenized paper, were placed in the hyposulphite solution as above for fixing, the image took a red or foxy tone, by no means agreeable to the artistic eye. It was found, however, that if prints were subjected to an old and long-used hyposulphite bath, a chemical reaction took place, which brought about an agreeable tone varying from brown to black, and thus for some time pictures were "toned," as it is termed. This process, however, proved deceptive, as prints thus toned were found to be liable to fade, and another method of toning had to be resorted to, which still maintains its place to the present day.

The silver print is, previous to immersion in the hyposulphite bath, placed in a weak alkaline solution of chloride of gold, when by a substitutive action the gold takes the place of the silver in the print, and the image, thus formed of finely divided particles of gold, assumes a variety of tones at the will of the operator, from a sepia brown to a dark purple or rich black; the fixing operation of the hyposulphite bath leaves these in their integrity, and there is thus obtained a monochrome image in a suitable tint according to the fancy of the operator. These, after undergoing a thorough washing to get rid of the hyposulphite compounds, may be considered as fairly permanent; but there are so many little circumstances and conditions connected with the purity of the paper on which the prints are taken and the care in washing, to say nothing of the atmosphere in which they are kept, that practically a large number of commercial photographs are found to fade and lose their brilliancy. Nevertheless, well-prepared photographs, on suitable paper thoroughly washed and kept in a dry atmosphere, may be considered permanent, or at least as permanent as a water-colour drawing.

The Daguerreotype, however, held its own for portraiture, inasmuch as a few seconds sufficed to impress the image on the plate, the Talbot-type requiring an exposure too long for the sitter to remain in one attitude. For landscape work, where the above objection did not apply, the latter soon became largely employed. Its manipulation was less complicated, its results were more agreeable to the eye, and its power of multiplication of copies were all in its favour. It is true that under some very special conditions of light and other favourable circumstances, portraits could be taken by it, and a series of such was shown with landscapes in the Great Exhibition of 1851. In spite of the greatest possible care in the selection of paper, and waxing it to produce transparency in the negative for printing, there still would remain a certain woolliness arising from the grain of the paper, which imprinted itself on the positives, and efforts were continually being made to get some other substance, which should serve as the foundation for the negative and be at once transparent and structureless. A film of albumen spread on glass was tried and duly made sensitive on the same principle as the paper, and produced very excellent results, but the process was slow and somewhat uncertain.

In 1851 the great revolution in the method of procedure took place. Archer published the collodion process, which has made photography what it is. Archer took collodion as the basis of his work. It is true that Le Gray in France had suggested this, with many other materials, as fitting for photographic work, and had, it is believed, actually produced pictures with it; but so little faith had he in its value, that he actually proclaimed, in his published treatise on his "wax-paper" process, that in his opinion "the future of photography lay in the paper processes." Whether Archer was or was not acquainted with Le Gray's suggestion does not appear; at all events he was the first to give to the public (for he took out no patent) a perfectly complete and practical collodion process, which, with very slight modifications, remains in use at the present day. Schönbein had just discovered guncotton, and it had been found that certain descriptions of guncotton were soluble in a mixture of ether and alcohol, and the solution was already in use for surgical purposes for producing a film or artificial skin to exclude the air from cuts and wounds. If this solution were poured over a glass plate, the spirits rapidly evaporated, leaving a thin transparent structureless film upon it, scarcely differing from the glass itself. Here was the very thing to hand, and it needed only to be rendered sensitive to light. Archer accomplished his objects thus. He introduced into the collodion a solution of iodide of potassium, and having poured the mixture over the glass, allowed the spirits *partially* to evaporate, and before the film was quite dry or set, he plunged it into a bath of nitrate of silver solution; a chemical reaction was at once set up, iodide of silver took the place of iodide of potassium in the film, and a sensitive plate was the result. On withdrawal from the bath, the plate, still wet, was exposed in the camera to the action of the image from the lens. On removal from the camera, the latent image (for as in the other processes no change was visible) was developed by pouring over it a solution of pyrogallic acid in lieu of the gallic acid, mixed with acetic acid, then fixed in the hyposulphite solution and well washed. A brilliant image on a glass-like substance supported on a plate of glass was thus obtained, and with a rapidity of exposure that at once rivalled the Daguerreotype, and, with the power of multiplication of copies, it soon took its place as the process for portraiture. Subsequently the introduction of a bromide in conjunction with the iodides, combined with the use of protosulphate of iron as a developing agent instead of pyrogallic acid, has been generally adopted, and by this means a greater rapidity of exposure has been gained, combined with a greater delicacy of gradation in tone.

Owing, however, to the process involving details of manipulation not readily available out of the studio, for the plates must be dealt with in a wet condition (and this required the aid of tents and the heavy *impedimenta* of sheets of glass and chemicals), paper still maintained its ascendency for out-of-door or landscape work. Sheets of prepared paper could readily be taken into the field, and with very simple and light appliances could be placed in the camera, exposed, and carried away, the process for bringing out the latent agent being deferred till reaching home, when the developing could be done at leisure. Many modifications of Fox Talbot's paper process were devised, but that which ultimately took the lead was the wax-paper process of Le Gray, alluded to before. In this the paper underwent a waxing process in the first instance, was then iodized by immersing it in a solution principally composed of iodide of potassium in whey, then made sensitive by treating it with aceto-nitrate of silver, and dried. The development was effected by plunging the exposed sheet into a saturated solution of gallic acid, to which, from time to time, as needed, a few drops of aceto-nitrate of silver were introduced. This was a very simple and sure process, giving excellent results, and was much in vogue. Ultimately, however, the collodion process has superseded paper, both for portraiture and landscape work. Tents and neat arrangements of convenient and of moderate weight have been introduced for working the collodion process in the field, and paper negatives have all but disappeared from the photographer's outfit. It is true that lately an attempt has been made to revive its use, and with some effect, and there is much to be said in its favour.

To get rid of the fatigue of carrying about the tent and other troublesome adjuncts so necessary for working the "wet" process—however light and convenient they may have been made—has engaged the attention of numerous workers in photography, and the production of a "dry" collodion plate which should admit of exposure in the field and the development at home at one's leisure, has been ever a desideratum. An infinite number of plans has been devised, and the attainment of a "dry plate," which should meet the requirements of easy preparation, rapidity of exposure, combined with the quality of keeping for a lengthened period in good condition, and excellence of results, has been anxiously sought.

If the collodion plate, after being made sensitive, be allowed to dry and be then exposed in the camera, even after again moistening the film with water, the development of the latent image is rarely satisfactory; and early attempts were made, and with considerable success, to keep the plate moist, by flowing over it, as it came from the nitrate of silver bath, some preparation which should prevent its drying for some time at least. Excellent results were thus obtained; but these processes are now superseded by the preparation of "dry" plates, which will keep for any reasonable length of time. The principle adopted has been to prepare the plate as for the wet collodion process, then wash it in several changes of water, and pour over what is usually known as the "preservative," but now more scientifically termed the "organifier," and set it up to dry. These preservatives consist of a great variety of substances; tannin, morphia, albumen, gelatine, gum, sugar, gallic acid, &c., either singly or in combination, have all had their advocates, and have, in skilled hands, turned out more or less excellent results.

It would be tedious to go through all the plans that have been adopted to secure success. Their name is legion. Probably that known as the Taupenot or collodio-albumen process, being a combination of the collodion and albumen processes, has been the favourite, in spite of the lengthened and tedious details of preparation. Still, when once made, the plates would keep an indefinite length of time, allowed a large margin in the time of exposure, were certain in their results, and, under the hand of a skilled developer, were of the finest quality, bearing comparison with best wet collodion plates. The great drawback, however, to all dry plates was the time taken up in their preparation, and efforts have of late been directed to obviate this objection and simplify the preparation, and if possible reduce the operation to the pouring over the plate a material which should need no washing or addition of a preservative, and, when dry, should be at once ready for the camera. The first step in this direction was the preparation of a sensitive collodion, thus getting rid of the necessity for the nitrate bath. It was an obvious suggestion, to add to the ordinarily prepared collodion a solution in alcohol of nitrate of silver, in the proper equivalent proportions, when the iodide of silver would be formed, and by the glutinous action of the collodion it would be held suspended in it, at all events for a considerable time. All that would then be needed would be to wash the plate, and add the preservative or organifier. Practically, however, difficulties arose, and it was not until a bromide was substituted for, or combined with the iodide, that success even thus far was attained, though there still remained to be got rid of the subsequent washing of the film, and the application to it of the preservative. The bromide of silver in an exquisitely finely divided state was held in suspension in the collodion, and the mixture partook of the nature of an "emulsion," by which name the process is known. To secure a satisfactory result, it was found necessary to add to the mixture in small quantities either aqua regia, a mineral acid, or a chloride, whilst nitrate of uranium was used successfully by one gentleman in the preparation of his plates. It was then further suggested, that if the emulsion thus formed could be washed, so to speak, and have the preservative added to it before it was poured on the glass plate, the necessity for subsequent washing and addition of the preservative could be got rid of. This has been accomplished, and we have now a completely prepared emulsion, which will keep an indefinite length of time, and which, poured over the glass plate and allowed to dry, presents us at once with the needful sensitive surface ready for exposure in the camera. The mode by which this result is obtained is extremely ingenious, and at the same time simple. The bromide of silver emulsion is poured into a flat dish, so as to form a moderately thick sheet, and the spirits are allowed to evaporate till the sheet is thoroughly set, not quite dry, but in a semi-solid state. It is then cut into small pieces, the preservative poured over it, and the whole well washed and allowed to dry thoroughly. This is then redissolved in a mixture of equal parts of ether and alcohol, and the emulsion thus produced fulfils all the necessary conditions for the production of the dry plate without further treatment. Such are the broad features of the process, but there are numerous minor details which have to be attended to, and which are the result of the researches and experiments of many enterprising photographers and men of science, amongst whom may be named Messrs. Bolton, Sayce, M. Carey Lea, Gough, Stillman, Col. Stuart Wortley, and Mawdesley. To apportion the merit amongst these would be a very difficult and invidious task. Suffice it to say, that to them is, in the main, due the complete and perfect condition at which dry-plate photography has now arrived.

Before quitting this portion of the subject, there is another material step in the progress of dry-plate photography which claims notice, and this is the introduction of the alkaline developer, with which the name of Major Russell is honourably associated. Hitherto we have seen that the developer always contained an acid, acetic, citric, and such like, but Major Russell taught photographers the important improvement of omitting the acid and substituting for it an alkali, such as ammonia, &c., especially where the bromide was used in lieu of the iodide in the collodion. This powerful developer has shortened exposure considerably, and has placed in the hands of the dry-plate photographer a new power.

Dry-plate photography, whether prepared by the emulsion process or otherwise, has now taken its settled place in the hands of the operator, especially for landscape work, and its results will bear safe comparison with the wet-plate work. Each has its special advantages, and circumstances as well as the fancy of the operator determine its use.

There is another emulsion process which of late has come into use. In this, the vehicle for holding the bromide of silver in suspension is gelatine, in the place of collodion. The process is remarkable for its extreme rapidity and the beauty of its results, as well as for its simplicity. The great objection to its use was that the mixture, especially in warm weather, decomposed rapidly, so that it was necessary to prepare no more at a time than was needed for the moment. Mr. Kennett, however, has overcome this by drying the emulsion and cutting it into small shreds, and in this condition it may be stored in packages, away from light, for practically an indefinite period. All that is needed, is to soak in hot water sufficient for the purpose in hand, and coat the plate with it. The development is conducted in the usual way with the alkaline developer.

Such are the processes in general use dependent on the use of the salts of silver, but photography has of late pushed its applications in other directions, and has for this purpose sought the aid of other chemical materials than silver salts. Some years since, Mungo Ponton discovered that paper which had been dipped in a solution of bichromate of potash and dried, was sensitive to the action of light, and subsequent investigations showed that this was due to the size or gelatine in the paper, and that a mixture of bichromate of potash and gelatine spread upon paper or glass, or a sheet of such material, was so affected by light as to become insoluble. This property, though it remained unutilized for some time, has now been largely brought into play, and forms the basis of innumerable patents, such as carbon or pigment printing, sundry engraving processes, photo-lithographic processes, printing, enamelling, and other reproductive and copying processes.

Allusion has been made to the uncertainty, in regard to the permanence, of photographs printed with the silver salts, and many attempts were made to produce photographs in other materials which should be lasting. Some of the earliest attempts in this direction consisted in taking advantage of the fact, that if paper covered with a film of bichromated gelatine be exposed to light under a negative, and finely powdered carbon or other material be brushed over it, the powder will adhere to those parts which have not been acted upon by the light, in proportion to the amount of light which has passed through the different portions of the negative, and an image was thus produced in permanent materials. The results, however, were not such as to lead to its general adoption, though latterly the "powder" process, as it is termed, with modified details, has been employed for the production of pictures on paper as well as of vitrified pictures in enamel, the powder used in the latter case being such as could be burnt in on suitable porcelain plaques.

Printing in carbon, or in any coloured pigment, has now become an accomplished fact, and is thus performed. A tissue, as it is termed, is formed by coating a sheet of paper with a solution composed of gelatine, gum, sugar, or treacle, or some such materials, with which lampblack or some other coloured pigment is incorporated; and this, when dry, is made sensitive by immersing it in a solution of bichromate of potash and dried. Exposed to light under a negative, the parts acted upon by the light become more or less insoluble, to a depth proportionate to the amount of light which has passed through the varying densities of the negative. It is obvious, that if we can now subject the under or opposite side of this film to the action of warm water, the soluble portions may be washed away, leaving a film of varying thicknesses, and therefore varying depth of tone, forming the picture. This operation of washing away from the back, which at first sight seems almost impossible, and which for a long time was a puzzle, is by a very ingenious and simple process readily accomplished. The tissue, after exposure under the negative, is wetted and brought into close contact by pressure, face downwards, on to a piece of gelatinized paper, already rendered insoluble by mixture with chrome or other alum. To this it adheres strongly; the whole is then dipped in warm water, when, after a few minutes, the soluble parts of the tissue give way, and the paper foundation on which the tissue was originally formed readily strips off. By continuing the action of the warm water, all that is soluble is thus washed away from the back, and the picture gradually develops, remaining firmly attached to its new support. It is then dipped in a solution of alum, which at once converts the gelatine picture into a leathery insoluble material. It is obvious that the picture thus formed is reversed right for left; and in order to get a satisfactory result by this process of "single transfer," as it is termed, a "reversed" negative must be used. By a process, however, of "double transfer," this difficulty is avoided, and the picture obtained in its correct aspect. The method of procedure is thus: The impressed tissue is wetted and laid face downwards on a zinc or porcelain plate previously wetted, then pressed firmly, so as to squeeze out all the water, when the tissue will adhere with sufficient force to admit of its being soaked in warm water and the image developed, as in the foregoing case, but in this case on the zinc or porcelain plate as a temporary support, in a reverse aspect, instead of on the paper as its final support. After dipping the plate in the alum solution and allowing the picture to dry, it is again wetted, and a paper, rendered adhesive by means of gelatine, similar to that used in the single transfer process, is brought into close contact with the image on the plate, and set up to dry. As soon as dry, the adhesive paper may be stripped off with the image adhering to it, but here again reversed so as to appear in its proper aspect.

Such are the main features of carbon or pigment printing, now brought to great perfection, and readily workable. It will probably become, in fact is already becoming, a formidable rival to silver printing, if it do not ultimately supersede it. It is obvious that a great variety of colouring matters may be used for impregnating the gelatine film, and thus results in varying colours and shades may be produced. Black or red chalk, thus made use of, enables veritable facsimiles of drawings in these materials to be reproduced. The charming sketches and drawings by old masters have thus been placed at the disposal of the public at a cheap rate, and by such a multiplication the works of our greatest masters have been brought within the reach of numbers who otherwise were debarred from their sight.

All these processes, however, involve the necessity for exposure to light for every copy produced; and thus where large quantities have to be provided, say for book illustration, for instance, it is extremely important, in a commercial point of view, to get some process by which, when once the negative has been produced, the multiplication of copies may take place, entirely independent of light. Fox Talbot very early sought to produce from a negative an engraved or etched copper or steel plate, from which impressions could be taken in the usual way in the press. He covered a steel plate with a thin film of bichromated gelatine, and exposed it under a negative. He then dusted the film with very finely-powdered rosin, and applied heat sufficient to just melt the fine particles of rosin-dust, the object being to form a grain. He then poured over the film a solution of chloride of platinum as etching fluid, which bit into the plate more or less deeply, in proportion to the time it took to penetrate through the film, which had become more or less absorbent, as the light had acted upon it through the negative. It produced very promising results, and the system has been improved and carried out with more or less success by others, but it does not appear to compete profitably with other later processes now in use with the same object.

Paul Pretsch, in a process termed photogalvanography, used bichromated gelatine as the base of his operations. He treated the gelatine film after exposure with water, when the parts acted on by light in a lesser or greater degree are more or less absorbed and swell in a greater or lesser degree. He thus got an image in relief or intaglio, according as he used a negative or a transparent positive. Taking a cast from this in guttapercha, or other suitable moulding material, he was enabled by means of the electrotype to obtain a deposit in copper, either as copper plate or surface block, for printing in the usual way. The results, however, required a considerable amount of skilled hand-work by the engraver, before satisfactory prints could be produced; but when thus treated they were remarkably fine, and perhaps have never been surpassed in quality by any subsequent process. Later inventions, of a less costly and less tedious character —for it took weeks to produce a plate—have entirely superseded it.

Woodbury, from whom the Woodbury-type now so largely in use takes its name, took advantage of the bichromated gelatine film, and having developed the image upon it by washing away the more or less soluble portions, obtained a film in which the image existed in the form of varying thicknesses, in like manner as takes place in carbon printing. Having got a film of this character, he proceeds to take a reverse copy of it in metal, by means of an Austrian invention brought out some years since, called "Nature Printing," i. e. he places the film on a hard plate of steel, covers it with a plate of type metal, and subjects the whole to enormous pressure under the action of an hydraulic press. The gelatine film imbeds itself in the type-metal plate, which, when taken out, is an absolute facsimile in reverse of the gelatine film. However strange it may appear, yet it is nevertheless the fact, that the film sustains little or no injury, and may be used many times over. Having obtained this type-metal plate, it is not, however, suitable for inking and printing in the usual way as a copper plate, for any attempt to ink it in that manner fails entirely, there being no grain or line to hold the ink. Mr. Woodbury was obliged to resort to another method for using his plate; he takes a strong solution of gelatine, into which finely-powdered carbon or any coloured pigment has been introduced, pours a pool of it on the plate, then applies to it the paper to receive the impression, and brings down a flat pressure upon it, spreading the gelatine ink over the surface, and squeezing out the superfluous gelatine at the edges. In a few minutes the gelatine sets, and, on taking off the pressure, adheres to the paper, turning out as from a mould an absolute facsimile of the original gelatine film, reproducing every detail and grade of tone displayed in the original photograph; in fact, a carbon print mechanically produced independently of light. After dipping in a solution of alum, these are practically indestructible, at least, in the same sense as engravings are, and they are largely used at the present day for book illustration, for which they are admirably adapted, by the rapidity and cheapness with which they can be produced, and at all times of the year, whether the sun shines or not.

An early method of engraving was adopted by the use of bitumen of Judæa, advantage being taken of the fact, that if a film of this spread on a metal plate be exposed to light under a negative, the parts acted upon by the light become insoluble, and then, by means of a suitable solvent, the parts unacted upon are washed away. There are a great variety of engraving processes more or less in operation, and among these, judging especially from the results shown in the last Paris International Exhibition, that by M. Placet, is one of the most beautiful, and at the same time simple. An ordinary negative is varnished, so to speak, with bichromated gelatine, and exposed, glass uppermost, to the light. The image is then developed with hot water, and a cast in electrotype taken from the picture, which stands in relief. He is said also to use a film of bitumen of Judæa as the basis of his operation. One great object in all these engraving processes is to obtain a grain on the plate which shall retain the ink, and Placet uses certain washes, the composition of which he did not disclose, which facilitated this in an eminent degree. When a film of gelatine acted on as above is dried, a certain amount of grain is always more or less developed, but there are various ways in which this may be obtained with a more vigorous action. Pretsch obtained *it, by mixing* iodide of potassium with the gelatine. If a film of gelatine be treated with a liquid having a tanning property, the surface, by the contraction which takes place, becomes covered with a grain, and this property has been taken advantage of for engraving purposes. Woodbury, however, produces a plate from which very successful results are obtained, by mixing up in the gelatine relief of the Woodbury-type, which has been previously described, a fine powder of a gritty character like emery flour. A metal plate obtained by pressure from this relief has necessarily a grain, which is found especially suitable for the retention of the ink, and very fine results are thus obtained. This process is now largely worked in Paris, and the results are of a very agreeable and artistic character.

The compound of the bichromate with gelatine, albumen, and such-like bodies, has been further brought into play in a variety of ways as a photographic agent in the reproductive arts, and successful as it is in producing a quasi-engraved plate, it is capable, when used as a printing surface itself, or as an adjunct to the lithographic stone or zinc plate, of faithfully reproducing every line and letter of the original; and besides, can be so used as to produce a matrix whence a stereotype block in relief, suitable for employment with the type in an ordinary printing press, can be obtained.

It will be remembered in speaking of the effect of light on the bichromated gelatine, that wherever it fell, and in proportion to its varying intensity, the film became more or less absorbent of water, and in an inverse degree capable of taking up a greasy ink like printing ink. From such a film so treated, in an ordinary printing press, a very large number of copies can be rapidly struck off, and very excellent facsimiles of the photograph in its varying gradations of tone are obtained.

The photo-lithographic process consists in covering a sheet of paper with a size, or surface of gelatine mixed with gum or albumen, in which bichromate of potash has been dissolved. The sheet when dry is exposed under a negative, and treated with a thin coating of lithographic transfer ink. It is then placed in warm water, subjected to gentle friction with a sponge or brush, by which means the ink is removed from the parts unacted upon by the light. The whites are thus left clean, the ink adhering only to the blacks. This sheet, or "transfer," as it is termed, is laid down on the surface of the stone, and subjected to strong pressure, when a set-off takes place upon the stone, which is then ready for the printer. The like process is applied to a zinc plate, whence we get photo-zincography, as it is termed, a process which has been largely used in the reproduction of maps and surveys connected with the Ordnance survey of the kingdom. It has also been applied to the facsimile reproduction of Doomsday Book, as well as other scarce and old volumes. These two processes are specially adapted to the reproduction of such works as the above, and to engravings where the effects of light and shade are due to the combination of lines and dots, but, unlike the previously-described process, are incapable of reproducing the shades and gradations of tone, or "washes," as the artist would term them, of the photograph proper.

Photo-typography is another extension of the photographic art, of large and increasing importance. By its means letterpress, engravings, pen-and-ink drawings, can be readily, rapidly, and accurately reproduced in the form of a block suitable for printing with the type. There are a variety of methods by which this desirable end may be obtained. A few hours will suffice for this purpose. The process may be called a modification of Pretsch's swollen gelatine process. The gelatine should be clarified in the first instance, and then placed to soak in water, after which it is washed carefully in a muslin bag in cold water, to get rid of any matter soluble in cold water. It is then placed in a glazed saucepan and heat applied; when melted, the albumen of an egg is added, and the whole raised to boiling point, by which means the albumen is coagulated, taking with it any impurities which may happen to be in the gelatine. Gelatine thus prepared has added to it bichromate of potash, to such an amount as not to interfere with the transparency of the gelatine, or crystallize out on cooling. A plate of glass duly levelled is then coated uniformly with it, and after drying is exposed under a negative, say for a quarter of an hour, in a moderate light. The plate is then placed in a flat vessel of cold water, when those portions of the film protected from the light, and representing the whites of the original printed matter, swell or rise in relief to such an extent, as to leave the other portions completely sunk. If a cast of this were obtained, it would represent the lines of the original in a raised condition, or ridge. The metallic cast or block may be procured by electrotyping, after giving the gelatine a conducting surface in the usual way, either by plumbago or bronze powder, or precipitating a thin film of silver on it by means of a wash of nitrate of silver, followed by a treatment of pyrogallic acid, or by subjecting it to the reducing action of phosphorus. A surface may also be obtained by first hardening the gelatine film, and taking a cast in plaster of Paris, from which a second cast is taken, to form the mould in which the stereotype metal may be cast direct.

The principle of the camera obscura is so well known, that it is needless here to say more, than that the image of any external object is by means of a lens thrown upon the sensitive plate. The details of the construction for the varied purposes of portraiture, landscape work, copying, enlarging or diminishing work, and such like, must be sought for in special treatises. It is obvious that if instead of the camera lens, the object-glass of the telescope be employed, images of the heavenly bodies can be obtained, and astronomical phenomena be recorded. The microscope again thus records its work. Those who are acquainted with optics, will readily understand how enlarged images may be produced from small negatives, and *vice versâ*. The production of minute images can also easily be secured, which, when viewed through a microscope, or cast on a screen by means of an enlarging lantern, become visible in all their minute details. This system was extensively made use of during the siege of Paris. A bulky mass of correspondence was thus enabled to be put in the smallest possible compass, on light films of collodion, suitable for the pigeon post, which after its arrival at its destination was easily read under the microscope, or thrown in an enlarged form on a screen, when it was readily copied by clerks employed for the purpose, and transmitted to its destination.

To produce a photograph which should render the subject in its natural colours, has long been the dream of the photographer and scientific man, and some foundation for it may be found in the fact, that under certain conditions the prismatic spectrum has been reproduced on the Daguerreotype plate, and also on specially-prepared paper, in colours distinctly approaching to those of the original. The image thus produced is however fleeting, and has not yet been satisfactorily fixed, and further, the colours themselves are wanting in brilliancy and thorough truthfulness; and the prospect of ultimate success in this direction is not very hopeful.

Monsieur Vidal has, however, been working in a totally different direction for obtaining a photograph in colours, and the specimens which I have had an opportunity of privately inspecting, show an amount of success which could hardly have been anticipated. M. Vidal makes use of bichromated gelatine films, coloured with the various pigments which he requires for the subject in hand. He then takes as many negatives as there are tints in the subject, and stops out in each such portions as do not relate to the colour and shade which he wishes to obtain. The coloured bichromated films are then placed under their corresponding negatives, and he thus gets a series of coloured films, which by an ingenious system of registration he puts together, very much after the manner of chromo-lithography, and thus builds up a coloured representation of the object, whether portrait, landscape, or otherwise. Such is the principle on which he works, and it is said that however complicate and intricate the details may at first sight appear, he has so perfected his system, that the work can readily be performed on an extended scale for commercial purposes. It is further stated that the process is worked in combination with chromo-lithography, but hitherto no details have been published. Hitherto the specimens have not been brought into the market, but it is expected that such will be very shortly the case, as M. Vidal has organized an establishment on an extensive scale in Paris, where he confidently expects to issue his works in large numbers and at a reasonable price. The specimens which I have seen are of a very remarkable character, and the perfection to which the process has arrived could hardly have been anticipated. Beautiful, however, as the results are, the process seems more adapted to the production of illustrations for trade lists and show cards than for portraiture, landscape, or works of a high artistic character. By the use of gold, silver or bronze powder as his pigment for the bichromated film, he obtains a truthful reproduction of trinkets or gold and silver plate.

The foregoing article must be taken simply as a sketch of the general bearing of photography in the arts, for it is not within the scope of this work to give a treatise on photography. Those who desire to practise the art, must seek for details in the special works on the subject.

TOYS.

By George C. T. Bartley.

In ordinary commercial transactions, we are so accustomed to fix our attention on those articles, whose use is principally confined to persons of adult age, whether by adding to their comfort, or for their necessary daily requirements, that we are apt to lose sight of the fact that children too have their wants, which are only to be supplied by those little trifles that we call Toys, and to ignore the extent to which their manufacture in England is carried on.

If we reflect for a moment, however, we cannot fail to be convinced, not only that the toy trade is one whose existence is an absolute necessity, but that its proportions must be very large. That such is the case, may be gathered from the fact that there are persons engaged in it, in every town, and in almost every village in England. It may be broadly stated that almost all of us, whether children or adults, require playthings in some shape or other; but even taking a more limited view of the matter, we may safely assert that not very far short of half the population is of an age to enjoy them.

I do not propose to enter into the consideration of the philosophy of play, or to dilate on the many important uses to which toys may be applied, either from a physical or an educational point of view. This would be foreign to my purpose, which is to exhibit their commercial side, and the mode of their manufacture. Though this manufacture is of considerable extent in England, it is very far from being the only source from which our toy market derives its supply. The English productions are almost entirely confined to a few special types of goods, which cannot be equalled by any other country, and are preferred not only in this country, but also on the Continent, to which they are largely exported.

Germany, Switzerland, and France are the great storehouses of toys. In these countries, labour is comparatively cheap, and the material—soft wood—of which so many articles are made, is also plentiful, and very readily procured. Each country produces special descriptions of goods, which find ready sale in the English market. The wooden animals, Noah's arks, carts, waggons, &c., are toys with which everyone is familiar. Many of the processes for the rapid manufacture, and consequent cheapening of these articles, are most interesting, and show that skill, ingenuity, and intelligence have been devoted in no small degree to their production.

It may be interesting to briefly describe the method of making wooden animals, &c., in Saxony. Strange as it may seem, the turning lathe is the principal machine employed, and by its aid batches of perhaps a dozen and even more of the smaller descriptions, are produced at a time. A ring of soft wood, varying in diameter according to the size of the animal required, *is turned by* means of cutting tools, in such a way that the outline of its section is the outline of the animal to be made, whether it be a horse, dog, camel, elephant or any other creature. The ring is then cut into pieces, each piece being in the rough, and nothing remains but the finishing, which is done by children. Not only are animals made in this way, but batches of wheels and various parts of many other toys, of which a great number of one shape is required.

Nothing of this sort has yet been attempted in England, nor is it likely, if it were, that we should be able to compete with our Continental neighbours—at any rate for many years to come—first, on account of the high price of labour in England as compared with that in Germany, Switzerland, &c; and, secondly, from the fact that the wood suitable for the purpose is not grown here; we should therefore be obliged to import it, and thus the cost of the raw material would be considerably enhanced.

The toy for which this country is chiefly celebrated is the *Doll*. The English doll is well known in all parts of the world, and is indeed *the* toy *par excellence* which takes precedence of all others. The doll is made in many parts of Europe; each country producing some distinctive character of its own, though nowhere is the doll to be compared to the wax one special of England. France only has any pretensions to vie with us in this manufacture; but the heads of the French dolls are usually made of china, and from their style, they do not altogether commend themselves as playthings to the children of this country.

Dolls are commonly classified by the trade according to the character of the head. However the body may vary as to shape and finish, the price is almost invariably regulated by the character of the head. The best descriptions only of dolls are furnished with regularly-formed hands and feet, and are made either of wax or china.

There are three sorts of English dolls in which wax is used in the manufacture of the head, namely, Wax, Composition, and Rag.

Wax Dolls form the highest and most popular class, and are always regarded as essentially an English production. The wax used is pure East Indian, simply coloured. A manufacturer may possibly employ some particular receipt of his own by which he thinks to bring out better results, or he may add some lower-priced ingredient, but it is doubtful whether the pure East India wax is not the cheapest, as it certainly is the best material for the purpose. Many other sorts of wax have been tried, but though several of them answer very well for a short time, the surface soon cracks, blisters, or behaves in some unsatisfactory manner.

At a large doll-making establishment, such as that of Mr. Edwards in the Waterloo Road, where thousands of dolls are frequently turned out in the course of a week, nearly the whole process takes place on the premises. In one of the rooms are several large vessels for melting which stand in larger ones containing water, kept at boiling point by jets of gas. The wax is put into the former, and is kept melted by the boiling water, without becoming burnt or injured. The colouring matter (chiefly rouge) is then stirred in, and any other ingredient which the technical knowledge of the doll-maker suggests. In this factory it is not uncommon for a hundredweight of wax to be melted at one operation.

The hollow plaster moulds into which the wax is poured are made in three pieces, from carefully prepared models, which vary in form and feature according to the style of doll to be made. Those used for the more expensive ones, are really wonderfully well executed. Many of the faces are artistically modelled, it being the special aim of the English makers to give the faces of their dolls a child-like expression, as they know their customers to be very fastidious on this point. The three pieces of each plaster mould are well soaked in water and tied together firmly, and when a certain number are ready, they are placed in rows, standing with the crown of the head downwards. The maker then fills a can with melted wax from one of the vessels, and, blowing away any surface impurity, carefully pours it into the moulds until they are full. In this way he fills perhaps a dozen, one after the other, the number depending upon the size of the head required. He then returns to the first one, and taking it carefully up, pours back into his can as much of the wax as remains fluid. This is repeated with the second and third, and so on with the rest. The greater part of the wax is in this way recovered, but that which comes into immediate contact with the *cold* plaster mould has already become hard, and forms, when the mould is untied, and taken off, the hollow wax doll's head. According to the time which elapses between the pouring the wax into the mould and the pouring it out again, so will the head be thick or thin: the experience and skill of the maker who does nothing else all day, of course, enabling him to determine this with great nicety.

Though the heads are thus cast, a great deal remains to be done before they are ready for the market. The eyes have next to be put in, and this usually takes as long as the casting, and indeed longer for the more expensive dolls. One man is altogether employed in putting in the eyes, which are of glass, and made for the purpose. With a sharp knife he first cuts away the wax for the sockets. In the case of smaller and cheaper dolls, he then slightly warms the eyes over a gas jet and puts them in their places. After properly adjusting them, he then pours a little melted wax into the inside of the skull, some of which coming in contact with the cool glass sets, and beds them in. He then rapidly returns the superfluous melted wax into his can. For the larger and more expensive dolls, however, a good deal more has to be done. Owing to the thickness of the wax, it would be impossible to make the eyes look natural in this way; consequently after fixing them in, he runs some melted wax over the front of the eye and models the eyelids and eyebrows with his hand. This of course requires considerable skill and long practice, and though the formation, when complete, may not be anatomically correct in every detail, yet the faces are modelled so well, that they look wonderfully natural. In those heads where the eyes are made to open and shut, the process is somewhat different. Both eyes are fixed together with wire, made into a sort of small fork with two prongs, the end of each prong being inserted in the hole at the back of the eye, and fastened together firmly with sealing-wax. The whole of this apparatus, that is the eyes and wire, is dipped into wax, coloured to represent the skin of the eyes, and is then fixed into the head, a little plaster of Paris being run round it at the back. Just before this plaster sets, the eyes are gently moved up and down with a long wire attached to the end of the handle of the fork. This keeps them free to move, when the plaster has firmly set. The wax over the eye is then cut away, and the process is complete.

The next processes are those of trimming, cleaning, and beautifying. As the joints of the mould necessarily show ridges of superfluous wax, these have to be scraped off, and the whole surface has to be rubbed over with a flat-iron tool, which makes it shine. As however the marks of the tool remain visible, the surface is brushed over with turpentine, by which all inequalities and any dirt or dust are removed, and the head is made smooth and shining, though the complexion of the face is anything but pleasant, and altogether different from that elegant texture which we are accustomed to see. This finish is given by a further severe brushing over the surface with violet powder, the effect of which is really remarkable, and the head emerges from the hand of the artist with that beautiful appearance, in which children so much delight.

Nothing now remains but to tint the cheeks, and to paint the lips, nostrils, and eyebrows, unless these last are to be furnished with real hair. The cheeks are tinted with rouge, and the lips and nostrils with paint, generally vermilion. It may be remarked, that the violet powder process is a most important aid to their colouring, for it gives a sort of rough surface to the wax, without which it would be almost impossible to get the colouring matter to stand.

The head is now complete, as far as the waxwork is concerned, though a very important part remains to be done, namely, the putting on of the hair, without which no wax doll would be saleable. That this is a matter of serious consideration with the doll maker, may be readily understood, when it is known that the hair is about the most costly part of the whole toy. In many, if not all of the best dolls, the hair and its insertion costs as much as the rest of the head put together, for a doll would not be considered a good one, unless it had the hair so put on, as to appear as much like natural hair as possible. This work is done by women. The head to be adorned is placed on a block, the operator holding lightly in her left hand a bundle of hair, which has been carefully disentangled with a comb made for the purpose, and drawn out into one uniform length. In the palm of her right hand, which she rests on the head, she has a short blunt knife, with which she lays the roots of the hair below its edge, and presses them about a sixteenth of an inch into the wax, quickly drawing away her left hand which holds the bundle. In this way the few hairs which have been pressed into the wax, remain in their place. She continues this manœuvre some eight or ten times, and then takes a sort of iron roller, and gently but firmly rubs it over the surface, and so closes the small gashes which she has made in the wax, with the knife, while pressing in the hair. She then repeats the whole process again and again, until the head is entirely covered.

It will be observed that this is a somewhat lengthy operation, though it varies of course with the number of hairs which are put in at a time. In the best dolls, not more than one or two are so placed. By this means a much more natural appearance is given to the head, but it necessarily takes a much longer time to do. In the common dolls, the hair is put on in locks, and thus the wig is soon formed. Sometimes when dolls are made to represent persons, and are either caricatures, or likenesses, if they can be called such, the hair is very carefully put in piece by piece, from a portrait which the workwoman has before her.

The material is of two descriptions. The black hair, which however is not so much used for dolls, is almost, if not entirely, human, and is imported from abroad in large quantities, while the light flaxen locks, which are generally preferred, and which are almost invariably placed on the common dolls, are of mohair. This material is specially manufactured for the purpose, and one house in London supplies nearly all the English, as well as the best French and German *makers.* It is of a remarkably soft and silky texture, and is sold in little bundles of different lengths. The mode of fixing it is similar to that just described as employed with real hair. Of course the great advantage of hair being put on in this way, is that children are enabled to comb and brush it, to part it, or to arrange it in any way they please. The best makers, such as Mr. Edwards, lavish a considerable quantity of hair on the heads of their dolls, which is so firmly fixed that they may be swung round violently by it without its giving way in the least degree. I have no hesitation in saying that dolls thus made, are about as good toys as can possibly be found. Children are never satisfied with playthings which are only to be looked at, but require such as they are able to finger and to do something with. Playing is not only grammatically an active part of speech, but it is essentially an active operation, and often expensive toys fail altogether to please a child, from this simple fact being forgotten. A girl will amuse herself for hours, with a doll whose hair she can comb and brush, whose face she can wash, and whose clothes she can take off and put on; but one which is costly, and too beautiful to touch, lest it should be spoiled, is a toy for which she will care little or nothing.

Most of the wax dolls have wax arms and legs, which are made by pouring melted wax into plaster moulds, exactly like the heads.

Dolls' eyes are now made almost entirely abroad. Some of the very best, however, like the artificial human eyes, are made in England, and are necessarily expensive. As eyes of this description are chiefly used for model dolls for exhibitions, and for such-like purposes, the number so required is comparatively limited. Formerly, nearly all the eyes were made at Birmingham, but in these, as in all small glass goods, the Germans are now able to drive us altogether out of the market. Hundreds of gross of these eyes, assorted in sizes, and packed in large cases, are imported into England annually; and although we are sorry to see the trade go out of the country, yet the doll maker must be now much more at his ease, inasmuch as he can always depend upon having an unlimited quantity, directly he orders them. Formerly, this supply was very precarious, and the eye makers were so dilatory, that the doll maker was often at a standstill for want of this very essential item.

The process for making glass eyes is very interesting. It is usually carried on at night, and owing to its being somewhat of a trade secret, it is with some difficulty that anyone is able to witness it. Each eye is separately blown, and as there are three colours in the better sorts, and two even in the cheaper, it is surprising how they can be sold at so low a price as they are. The foreign eyes for the cheaper dolls may be procured for a few shillings a gross, though a pair of the best English doll's eyes cost a guinea.

I now come to consider the *second* class or *Composition Dolls.* These are very much cheaper than those made entirely of wax, but are stronger and can stand considerably more knocking about. The main difference between the two is, that the latter are of solid wax while the former are made of paper, with a wax covering or coating The mode of making the composition heads is, however, altogether different from that employed for the manufacture of the wax ones.

In the moulding process, a man takes a number of pieces of paper (any coarse rough material will do for the purpose), and after well saturating them with paste and water, places them in layers so as to form a soft pulpy sheet, varying in thickness from a thirty-second to a sixteenth of an inch, according to the size of the head which he is about to make. He then takes the sheet and places it over a mould of hard metal representing half a head cut vertically behind the ear, and with a sort of pestle, forces the wet pasteboard into every minute crevice of it. He places another similar piece on another mould corresponding to the other half of the head, and works it in the same way. When nearly dry, the two halves are removed from the moulds and pasted together, the portions when they are joined being covered with a piece of paper. The head thus far moulded into form, is as hard and almost as tough as leather, and has very much the same appearance.

In this state it reaches the doll-maker's manufactory. Probably a large dealer will have hundreds, if not thousands, of these paper heads on his premises. Little care is taken of them, as they cannot spoil, and it does not matter how dirty they become, provided they are kept fairly dry. When it is proposed to complete them for the market, they are finished in the following manner. First of all, they receive a coating composed of size and whiting, and when dry they are washed over with a solution of oil, turpentine, and other ingredients, which takes off the dead white, and puts on a yellow complexion, at the same time giving them a surface which will retain the wax used for coating.

At this stage, the eyes have to be dealt with. The workman cuts out the sockets for the eyes with remarkable accuracy and precision. He then takes an eyeball from the store, fixes it to the top of his right forefinger with a lump of paste, puts it up the inside of the head, and, almost in a twinkling, it is in its proper position, and coated with more paste, which is manipulated with his left hand from the front of the face.

The eye being completed, the face next receives some rouge on the cheeks, and nothing more is done till the paste is dry. Then comes the waxing process, which consists simply in dipping the head in a vessel of melted wax, and this is repeated, until the head has then all the appearance of solid wax. I ought to mention, that the workman, before giving the first dip, breathes on the eyes; the object being to moisten them sufficiently to prevent the wax adhering and giving him trouble to scrape it off. The moisture from the breath condenses on the glass eye, so that when the workman cuts out the piece of wax, which of course covers the eye, like every other part, it drops off at once, leaving the glass clean and bright, and not requiring any further touching up. The wax is now scraped off from that part of the head which the hair will cover, with a view to economize this material, so costly to the doll maker; and the head is passed over to a boy to be manipulated with the violet powder, as before described. The next process is that of painting the eyebrows, lips, and nostrils, and of rouging the cheeks.

The hair in these composition dolls is put on quite differently, and is almost always composed of mohair, a certain quantity of which is allowed for each dozen heads, and is carefully measured out to the workwoman, who, sitting before a small gas stove—on the top of which some half-dozen curling irons are kept hot—proceeds to curl it. In order to secure the permanence of the curl, the ends of these irons have to be made so hot that they cannot be touched without burning the fingers, but the operator dexterously twists the end of the mohair round them, and soon completes a dozen ringlets. These, varying in length according to the sized head for which they are required, are then taken by another woman, whose duty it is to fix them in their places, by cutting a deep groove completely through the skull, along the top of the head, where the parting is to be. She then pushes the uncurled ends of the ringlets one by one into this groove, at the same time inserting a lump of paste with a little blunt knife; she then flattens down the hair at the parting with a little more paste, and the head, adorned with a crop of luxuriant flowing curls, is complete, and ready for the body to be attached to it.

The third class of doll is essentially English, and is that known in the trade by the name of "Rag Doll." This is almost a misnomer, however, as will be seen from its manufacture. The rag doll consists of a wax back, with a piece of linen stretched over the *surface of the face*, which gives the wax a very soft and pleasant appearance, and renders it less liable to damage. The process is as follows:

A mould of the faces is taken from a carved block, the melted wax poured into it, and the superfluous wax poured out as before. The cast thus produced has all the appearance of a small wax mask; the cheeks are then rouged. Another mould, exactly like the one in which the wax was cast, is now taken by the workman, who places it on the table before him, with the face downwards, and lays on the top of it a piece of thin muslin. He then places the wax mask on the muslin, and gently presses it into the mould, with a round rammer, and in this way the wax necessarily adheres so closely to the muslin, that it becomes a sort of skin to the mask. The whole process takes but a few moments, and the face comes out complete. It may require, if it be a rag doll of the better class, further painting; but the colouring which has been put on to the wax is visible through the muslin.

As a rule, these rag faces, as they are called, are not furnished with the remaining part of the head, but are fastened to a skull, which is part and parcel of the body of the doll, and, like it, made of calico and stuffed with sawdust. A cap is then dexterously placed on the whole, leaving only the face visible. Some makers, however, complete the head entirely by two blocks cast both for back and front of the head, by which excellent dolls are produced. They are, however, but little stronger than those made of the pure wax, and not nearly so durable as the composition dolls that I have previously described.

I must now say a few words on the bodies of the dolls, which are mostly made of calico, stuffed with sawdust. Some of the more costly ones are covered with kid or thin sheep-skins, and are more carefully stitched and jointed; but the staple trade is in the cheaper description. These bodies are chiefly made by women, assisted by the younger members of their families, each of whom takes one special part. In this respect the manufacture resembles the match-box trade, carried on so largely in the East end of London. The doll manufacturer gives out so many yards of calico, and he knows to an inch how much each dozen dolls will require according to the size. The body maker takes it home, cuts it up, and makes it into the proper shape, fills it with sawdust, which she has herself to find, and sews up the trunk at the neck. One person cuts out, another sews up, a third rams in the sawdust, a fourth closes and makes the joints, and in this way a family will produce many dozens in a week. Of course the payment is by the piece.

The arms form again another branch, upon which certain persons are almost exclusively employed. Except for the very commonest class of doll, it is the custom for the arms to be made of two materials, the part above the elbow, of calico, and the part below, of leather. The price paid for these arms made complete, including material—for the doll manufacturer does not supply his employés with either the calico or leather—is almost incredible. Large arms, about six inches long, are worth 6½*d.* a dozen pairs; the small ones for the very cheap dolls, only cost 1½*d.*

a dozen pairs. The arms, it is true, are not modelled very carefully, but even in those at the latter price, there is always an attempt at fingers, though their number may not be exactly correct.

The putting of the head, arms, and body together, is the last process in the doll-maker's trade. This is soon done, with glue and thread, and after wrapping the whole in delicate silver paper, the article is ready for the market. A sixpenny doll may seem a very insignificant thing, but from what I have said, my readers may wonder how it can be produced at all at such a price. A sixpenny retail doll should cost not much more than threepence, if the maker and the retailer are to get a living. Out of this threepence, all the workpeople have to be paid, and the material to be supplied as well.

To make a composition doll at least twenty different persons must be employed, not reckoning those who manufacture the raw material, such as the wax, the glass for the eyes, the calico, and the hair. This will give some idea of the number of people who are engaged in this country in making these apparently trivial articles. In London there are sixteen doll manufacturers, that is, persons who produce the articles wholesale. The number of retail dealers it is impossible to calculate, for so few confine themselves to the sale of toys; and moreover a large number of general dealers in articles of food and miscellaneous goods, in the poorer districts of London especially, also combine the doll trade with their many other branches.

The greater number of the dolls are sold undressed, and one great use of these toys is, that they may be made to teach children how to make the articles necessary for their toilets themselves. Some dolls are, however, very magnificently attired by the makers, and each large manufacturer has a staff of young women employed in this way. The style and taste is often somewhat strange, but as a rule the mistake is not so frequently made with the English as with the French doll, namely, that of dressing it up in the costume of a fast young lady. English dolls, which are really meant to be playthings, are generally dressed as children, as of course they should be. The rag dolls are always sold ready dressed, probably from the fact that, as a cap is necessary to give a finished appearance to their heads, it has become the custom to complete their attire. As these dolls are sold in very great quantities, it may easily be understood that a large number of women must always be employed in this branch of the trade alone.

DOLLS' BOOTS AND SHOES.

The manufacture of these articles constitutes a special branch of trade, though, of course, it is only the more expensive dolls to which is usually granted the distinction of being possessors of real leather shoes. The demand for them is sufficiently great, however, for Messrs. Gibbs, of Clerkenwell, to make this one of their spécialités. These liliputian articles are produced from the waste material left during the manufacture of the ornamental boots and shoes worn by children, and they are made in exactly the same way.

A woman takes one of the scraps of leather, or felt, or other material which has been thrown aside by the person making the larger shoes, and, by means of a cutting die and a screw press, stamps out a piece of the required shape, so arranging the die at each cutting that she may get as many as possible from the one remnant. The number of pieces required for a pair of doll's shoes or boots varies with the description of shoe or boot wanted; but never less than three, and sometimes four or five, separate cuttings, have to be made to complete the article. These pieces are then tied up in bundles of half-a-dozen pairs, and given out to women to make up by piecework. The sewing machine comes in here very usefully, and with it the little pieces are stitched together, and an ornamental pattern of thread generally added by way of finish. The soles are cut out in the same way, though they are put on to the uppers by hand.

The number of these articles produced is very great. At Messrs. Gibbs' establishment alone, about a thousand pairs are made weekly, and they employ one machine exclusively for this work.

TOY BOATS.

This is a very characteristic toy in the English market. England being a maritime nation, it would be strange, if ships and boats were not extensively dealt in as toys. The rigged ships require as much nicety in their construction as almost any toy, i. e. if it is intended for them really to sail. Mr. Sanderson, of Berwick Street, Oxford Street, is one of the chief makers of yachts and ships of every description, and I cannot do better than describe the manufacture as carried on in his establishment. In the first place, the deal, of which the hull is made, has to be obtained as free as possible from knots and flaws. This is then cut up into blocks varying in size and thickness, according to the class of vessel required. A regular series of numbers is used, from No. 1—a rigged boat, the retail price of which is sixpence—to No. 8, a twenty-five-shilling ship. To the block of wood is first nailed a brass frame, representing the contour of the hull, and round it the outline is drawn in pencil, and the frame removed. A boy then slices down the block to this line, and hands it to a more experienced workman, who chisels it into the proper boat shape. Another boy finishes it off by first scraping the sides, &c., and then making the whole smooth with sandpaper. If the vessel is one of the smaller craft, a piece of sheet lead is now nailed on along the keel. If, however, it be one of the larger description, the lead for the keel has to be carefully cast, and is not fixed until the vessel is otherwise complete, for considerable care is required, so as to ensure a proper equilibrium when afloat. The sides of the deck are then nailed on in the smaller boats, but in the larger ones the hull is first hollowed out with a gouge, and a deck is nailed on before the sides are fixed.

The mast, or masts and bowsprit, are then put on, the ropes and rigging attached, and the hull painted. When this part of the work, which is done by women, is completed, the sails are attached, and the ship is ready for market. The name of the vessel and the port from which she hails are put on to order. A maker on a large scale, such as Mr. Sanderson, keeps labels on which are printed the names of almost every port in the world; so that if he received an order, say from Melbourne, he would put "Melbourne" on the stern, and so on. A neat arrangement is adopted to facilitate packing. Instead of the masts being taken out, whereby the rigging would be disarranged, they are sawn across, just half an inch above the deck, the two ends being connected by a ferrule which slides up and down. In this way the mast may be laid on the deck in a moment, and the sails packed up without the least trouble or damage to the rigging.

Each vessel has to go through as many as fifteen different hands before it is complete: and though the whole of the work, as we have seen, is done by hand, the manufactured article is sold at a remarkably low price. The number of these toys annually produced in the country it is impossible to estimate. At this one establishment alone, however, no fewer than ten thousand sailing boats are made every year. Upwards of five hundred 12-feet lengths of 3-inch deals are used in their construction, and the weight of lead required for the keels is not less than 8 tons.

THEATRES AND GALLANTY SHOWS.

The Theatre.—This is a species of toy which is in great demand, though it is difficult to understand how children manage to use it, or find much pleasure in it. Many thousands are sold annually, however, and at one establishment alone, no fewer than twenty thousand are completed every year for the home and foreign trade. The number of pieces which go to make up these toys must be noticed. First comes the framework of the theatre, which is of wood. It is so contrived that it will fold up into a flat, and open out into a rigid and substantial stage, with drop curtain, side wings, and back scene complete. The ornamental part of the stage front, the orchestra, and the scenes, are composed of gaudy-coloured prints pasted on thin cardboard. The figures for the play are of a similar description, and are generally left in sheets for the children to cut up. These, with the book of the words, complete the properties, the whole of the cheaper descriptions being sold for a shilling retail.

The Gallanty Show is a rather less elaborate toy. It consists of a framework with a sheet of thin paper stretched across it. A candle is placed behind this, and cardboard figures are danced by the children behind the paper. By this arrangement of the light, their shadows, and not the figures themselves, are seen by the spectators. These figures are all cut out before they are sold, and this process is done by hand, for it is found cheaper to do this than to have them stamped out by dies. It seems a strange medley, but a great many of these theatres and gallanty shows are produced by the same maker whose specialty is the sailing boats, just described.

INDIARUBBER AND VULCANITE TOYS.

The development of the manufacture of articles in indiarubber and vulcanite has of late years been great. These substances are applied to so many useful purposes, that at the present time we can hardly understand how we managed formerly to do without them. Mention of some of these purposes will be found in another volume of this series, but I have now to do with their special adaptability to playthings. The trade in vulcanized indiarubber toys is now very large, and an infinite variety of articles are made, comprising dolls and animals of every description. The following account of a visit to Messrs. Laing's manufactory in Cowcross Street will give a fair idea of the general mode of the manufacture.

The indiarubber is first of all cut up into small pieces and mixed with white-lead and a variety of substances, more or less special to each maker. It is then rolled out into sheets of different thicknesses, according to the character of the goods required. The material thus formed is altogether unlike the vulcanized indiarubber, as we know it. It has more the nature of putty, and has no elastic properties whatever.

The next process (in making a doll, say) is that of moulding. The mould is of iron, and in two pieces, dividing the doll from side to side. These two parts are laid on the table, and the workman takes two sheets of the prepared indiarubber, and very roughly forms each of them into the shape of one of the half moulds. He pulls out a piece where the nose is to come, pushes in his fingers where the eyes are situated, draws out a piece for the arms and legs, and so on. In this way he gets each sheet fairly to fill the mould. He then puts the two half moulds one on the top of the other, and screws them firmly together.

When he has thus filled a large number of moulds, perhaps some hundreds, he places them in the vulcanizing bath, which is a close vessel filled with sulphur and other ingredients at a high temperature, and leaves them in it for several hours, the time varying with the size and nature of the articles to be made.

When taken out of this bath, the indiarubber has become elastic, and beyond the trimming of the edges where the moulds joined, and painting, if this be required, the toy is completed, be it a doll, an animal, or what not.

The guttapercha toys are made in altogether a different way. They are not nearly so neat as those of vulcanized indiarubber, but, being cheap and showy articles, there is and always will be a great demand for such goods, and for these reasons they are often preferred. Guttapercha merely requires to be warmed in hot water to be moulded into any shape. The material is rolled out in sheets, warmed, and then pressed into moulds, and afterwards dropped into cold water, when the moulded object is completed. A vast number of dolls' heads are made in this way, and, after being simply painted, are ready for the fixing on of the bodies.

Vulcanite toys must also be mentioned as belonging to this class of manufacture. This trade has only grown up of late years, and is now an industry of no small proportions. Vulcanite is simply a prepared indiarubber. The indiarubber in this case undergoes a different process to that which I have before described; various ingredients are mixed with it, and it is then rolled out into thin sheets and baked in an oven. When the sheets are taken out they are hard and jet black, looking really as much like jet as anything can do; they are then ready for use, and all that remains to be done is simply to warm them, and to cut out, with a stamp, the article required. If necessary to give it any little extra finish, such as an ornamental edging or other embellishment before it cools again, it is pressed into a mould. After this, it is polished so as to make it as bright as possible for the market.

The manufacture of indiarubber and guttapercha goods has now become a large and important industry, for we see them for sale in all directions. Messrs. Laing, though making many other articles from this material, may be considered as special producers of this class of toys, and it is to their kindness that I am indebted for a personal investigation of the processes employed in this manufacture.

CARD AND PAPER TOYS.

The manufacture of toy playing-cards may be thought a small matter, but it is surprising what enormous numbers of such articles are produced, and at what prices they have to be made. Some persons may think that there can hardly exist a demand for packs of these liliputian toys, even if the packs are perfect, which some will probably doubt. But if they were to visit the factory of one firm alone, that of the Messrs. March, of Woodbridge Street, Clerkenwell, and inquire for themselves, they would arrive at a very different conclusion. This firm manufactures packs of cards of three descriptions, known in the retail trade as the halfpenny set, the penny set, and the twopenny set. The penny set is perhaps the most popular, and I will explain how it is produced. In the first place, a particular kind of paper has to be made, as from its peculiar size it is useless for any other purpose; a ton of it is generally made at a time, so that it may be rendered at the lowest possible price. Messrs. March use five or six tons of this paper annually. To give some idea of what a ton represents in packs, it may be mentioned that the paper is very thin, weighing only 17 lb. to the ream of 480 sheets. In a ton there are 2240 lb., or 132 reams of 17 lb. each, and as there are 480 sheets in a ream, it follows that in a ton there are 63,360 sheets. On each sheet three packs are printed, so that a ton of paper represents the enormous number of 190,000 packs of cards. At this one manufactory, therefore, about a million packs are made, containing no fewer than 52 million separate cards.

The paper is printed by steam power in two colours, viz. red and black, and as it makes practically no more expense, the court cards, which are placed in the middle of the sheet, receive a little of both colourings, and look more imposing in bright red and black when complete, than they would if only of one colour. When printed, they are dried and pressed in the usual way. Each sheet then has to be pasted to a piece of card or "middlings," as it is technically called. Two persons are engaged on this; a girl makes up a pile of cards and printed sheets, placing one on the other alternately, while a man pastes each card and printed sheet together with very thin paste, and after they have been squeezed in a press for some little time, they are hung up for two or three days on clothes' lines with ordinary pegs, to complete the drying.

The next part of the business is to cut them up, a process done entirely by girls. The three packs on each sheet are first separated by hand, with a pair of shears. The suits are divided off in strips by a cutting machine, and laid one upon another crosswise, in piles, and then carefully tied up and put by for store. When they are required to be completed for sale, a girl takes one of these bundles, adjusts the hand-cutting machine, and cuts up the strips into simple cards in an incredibly short time. Four strips, that is, two red and two black, go to a pack, and as each pack is completed, the girl takes it and places it in one of the pigeon-holes of the case before her, which holds a gross of 144 complete packs. Nothing then remains, but to do the packs up in different coloured pieces of paper with a little paste, and then to tie them up, placing one of the court cards on the outside. This is usually not an extra card, though some makers are so liberal as to throw one in, over and above the fifty-two required. It will be seen, however, that at Messrs. March's establishment, if this were done, nearly half a hundredweight of the ton would be used in these extra cards alone.

The girls employed at this work make good wages. They are paid by piecework entirely, and a smart young woman can cut and complete six gross or 864 packs of cards per day (in cards the rule of the trade is twelve dozen to the gross), by which she would earn about one pound per week. Some of course are slower, and never reach this point, but, generally, slow hands are not employed by the manufacturer.

The manufacturer's price for these penny packs is 5*s.* a gross, or somewhat less than half that of the retailer to the public. As a rule, the maker of penny articles rarely receives more than half the amount at which the goods are sold by the retailer. He of course has first to deal with the wholesale house, and so there are two parties to share in the difference between the manufacturer's and the retailer's prices. The greatest profit is made by the retailer, who, however, it must be remembered, has as much trouble, and perhaps even more, to dispose of a penny pack of cards, as a superior tradesman has to sell a shilling or a half-crown article. For the colonies too the price has most carefully to be considered. Five shillings a gross is the highest price that an export house can pay for penny goods. However, taking a thing which is to be sold in Australia for a penny, even sixpence a gross over the five shillings in the wholesale price renders it useless to the trader, for his profit goes at once. Many thousand gross of these cards are sent to the colonies, and to all parts of the world.

The halfpenny cards are made exactly in the same way as the penny ones, except that they are smaller, and six packs are printed on an ordinary double-crown sheet of paper. This saves the maker a little paper; and besides this, he pays three-halfpence a gross less than he does for the penny packs, for cutting the cards and doing them up. These are the only items in which the halfpenny articles differ in cost of production to the penny one, and the wholesale price of them is 2*s.* 10*d.* a gross.

The twopenny packs are regarded as superior goods altogether. They are precisely the same, however, as the penny packs, with the addition that each card has an ornamental paper back. This paper is either green with gold stars, which costs a guinea per ream of 480 sheets; chocolate and gold, which costs twenty-eight shillings a ream, or some other pattern which greatly adds to the appearance of the cards. Their sale, however, is not nearly so large as that of the penny packs. It is a remarkable thing, that when the retail price of an article gets above a penny, it at once shuts it out from a certain class of the buying *public.* Indeed, so much is this the case, that it might almost as well be fixed at sixpence, for then it is bought by another section of the public, who, as it were, regard sixpence as the minimum sum for expending in little things. The spending public go in sets. There is the farthing set, who patronize small sweet and toy shops, and who are mostly children; then there is the halfpenny set, and the penny set. After this comes a jump to the sixpenny set.

It may be asked, how is it that these packs are not charged with duty, similar to that levied on playing cards? The fact is, that being regarded as toys, they are specially excluded by Act of Parliament from this tax, on condition that they are under a certain size; this fact adds, no doubt, to the importance of the manufacture, and it is almost unnecessary to say that any tax on them, even if only a halfpenny per pack, would at once destroy the trade altogether.

The manufacture of toy picture-books must be mentioned in this class. The sale of penny, halfpenny, and farthing books, at retail price, is most extensive. Plain printing in black, however, is not sufficiently attractive, and even the farthing books have a picture on the cover printed in *four colours* by Messrs. March. The contents of these books are generally confined to pictures, and the blocks from which they are printed are electrotypes from wood. Four copies of each book are printed on one sheet, and the printing is on one side of the paper only. When the printings of the different colours are complete, the sheet is cut into four parts, each part being folded so as to form a complete book. The wholesale price of these little books per gross (thirteen dozen being reckoned to the gross) is:

	s.	d.
For Penny Books	5	0
„ Halfpenny Books.. ..	2	6
„ Farthing Books	1	3

Valentines may perhaps be included with toys, or at any rate the penny and halfpenny ones, which can hardly be looked upon as anything else. Some interesting facts concerning these articles, with which we are so familiar, may be mentioned. At the present time three sorts are in vogue. The halfpenny, or 8vo; the penny, or 4to; and the long shaped, this last being the latest novelty. They are all printed from wood blocks, and very rarely from stereotypes. The reason of this is, that fashion has to be very much studied. The style of headdress of the period is a great consideration, and in fact many of the most successful valentines are caricatures on certain extravagant modes of dressing, fashionable at the time when the valentines are issued.

The penny and the halfpenny valentines are both printed from the same block, the sole difference between them being in the size of the paper. This is the only item which affects the cost of production, but when it is stated that the wholesale price at which they are sold is 2*s.* a gross for the penny ones, and 1*s.* 9*d.* for the halfpenny ones, it will be understood that really the retail prices of a penny and a halfpenny are, in both cases, quite fancy ones, and bear no *proportion* to the cost of production. The long valentines which are now in vogue also sell retail for a penny, but the producer obtains 4*s.* 6*d.* a gross for these, which is a very much higher price than what I have just mentioned for the ordinary articles. The cost to him is somewhat more than that of the former, but not anything at all proportionate to the increased price which he receives for them.

The painting of these valentines—and it need hardly be said that they would scarcely be considered valentines at all, unless they were very gaudily and brightly coloured—is done by hand, and very rarely printed in colour. Women are employed on this work, and the amount which they receive for it is at the rate of 3*s.* a thousand. Even at this price, however, a very good living is obtained while it lasts, though in industries, such as this, which only gives employment for a limited period, the work for the time is often excessive, but is soon finished, and gives no lasting occupation to those engaged in it. When a valentine has a run, the stencilling process is sometimes employed for colouring it, by which about sixpence a thousand is saved.

Pewter Toys.

Perhaps few toys are more popular with children than those made of pewter, and there are certainly few whose mode of manufacture is more interesting. Though there are only three manufacturers in a large way of business in London, there are other large towns, and particularly Birmingham, in which these articles are produced in much greater quantities. Mr.

Bull, in Wellington Street, Newington Causeway, is one of the largest makers in London, and, with his father before him, has carried on business for more than seventy years.

Everybody is familiar with pewter toys, such as the sets of metal tea-things, the dinner services, the coffee sets, the pretty little filigree baskets, and the metal articles of all descriptions, which are made in fabulous numbers and variety for Christmas trees. These are all of pewter, and each one is cast by hand. In the first place, I must speak of *the metal* used, where the skill and experience of the maker come into play, as regards the proper mixing of the old tin and lead, of which it is an alloy. Everything depends on this; two batches of material are rarely alike, and it requires a considerable amount of practical experience, so to proportion each metal, as to adapt the alloy for the objects about to be made. If new bar metal only were used, this difficulty, of course, would not exist, but as it is used comparatively seldom, owing to its cost, and the alloy is composed of old tin and pewter articles of all descriptions, the difficulty is unusually increased. The marine-store dealers buy up metal goods of all kinds, which are sorted out and sold by the hundredweight, the pewter toy makers being among their best customers. Anyone visiting Mr. Bull's works will see some dozens of sacks of miscellaneous articles, such as candlesticks, plates, teapots, pots and pans of all sizes and shapes; and from these, melted down with old lead and a little new metal, the pewter *is made.* Many of these old tin articles contain foreign substances, particularly antimony, which is very apt, without considerable practical experience, to spoil the pewter.

The metal being melted in a large iron vessel over a small coke fire, two workmen or women seat themselves facing one another on either side of it, and proceed to the manufacture of the toys. These are divided into three classes: first, those cast and poured out; second, those cast complete in a four-piece mould; third, those cast solid in a mould consisting of but one piece.

The first process is only adopted for teapots, coffee-pots and such-like articles. It resembles that used in the manufacture of dolls' wax heads, except that it is done very much more quickly. Supposing a teapot is to be made, the maker takes a four-piece mould of hard gun metal, and after fixing the pieces closely together, he holds it with a thick pad in his left hand. He then quickly fills it from a ladle with the molten pewter, and no sooner is the mould full, than he pours as much as he can of the metal back again into the ladle. Sufficient pewter cooled by the mould remains to form a thin shell of metal, and the teapot is complete, with the exception of what is required to be done to the spout and the lid. In making these things, it is very necessary to be careful as to the heat of the mould. If it be not kept cool, the metal when poured in does not solidify rapidly enough, and consequently the process fails. Not more than two articles can be made, without the pieces of the mould being cooled. Again, if the mould be too cold, the sides of the teapot, or whatever else is being made, become unnecessarily thick, and the spout may be solid to excess. The practical knowledge, necessary for the accurate arrangement of these little details, is only gained by considerable experience.

The process of making pewter toys cast complete in a four-piece mould, is the one by which nearly all the teacups, sugar-basins, plates, and such-like articles are produced. Women and boys are employed, and can turn out an astonishing number in a day. The mould is, as before, made of gun metal, each article being separate. This is put together and held in the left hand, while the metal is poured in with the right, after which the mouth of the mould is dipped in water, the mould itself taken apart and the article removed, nothing further being required than the trimming off. In this process the mould may be allowed to get hot without any detriment to the toy; indeed, if it be too cold, the metal will not run into it so well. One girl will thus make 2500, or seventeen gross of the small cups, in a day; of course the larger ones take more metal, and the number produced will be proportionably less. The lids of the teapots, the plates, the sugar-basins, the candlesticks, &c., are all produced thus, and are complete as they come out of the mould, with the exception of trimming. Spoons, forks, and such-like articles are also cast in this way, but in sets of half-a-dozen at a time, which are afterwards cut up.

This mode of making pewter toys and completing them in one operation is, however, comparatively recent. Formerly every article now produced by this second process, except spoons and such-like things, were turned, after they had been thus moulded. Each plate, teacup,

&c., was put into a lathe, and the workmen with a chisel trimmed it round inside and out, and put a sort of rough engine-turned pattern on it. When finished, these looked very much better than those now made, and for a few special sets this process is still resorted to. The great desideratum, however, is to manufacture very cheaply and consequently as rapidly as possible, and hence the tedious process of turning has been done away with.

Pewter toys cast solid in a one-piece mould look very much like wirework when finished. Christmas-tree ornaments are made in endless variety in this way. Birdcages, firegrates, and baskets are cast in one or more flat sheets and then doubled up into shape, the pieces or ends being secured by little projecting pins, which are in readiness to be turned back in the form of hooks and locked into one another. Farthing chairs are also cast flat and then bent into shape. Figures of men, fiddles, railway trains, and other such-like toys are complete as they come from the mould. The number and variety of these articles are so great, that it is impossible to attempt to enumerate them here.

The following is the method of manufacture. The mould consists of a flat metallic block on which the pattern of the article required is carefully engraved. Where the ornament and other details are required to be in relief, the mould is more or less deeply countersunk, according to the appearance which the toy is desired to assume when finished. The block in fact is somewhat like a wood-cut butter stamp, only much finer, or rather, perhaps, more like a die for stamping. A funnel-shaped trench is cut in the top of the block, the small end of which leads to that portion of it which is countersunk. The maker then places the engraved face of the block (with the large end of the funnel looking upwards) against a piece of flat stone, placed somewhat obliquely on his table before him, and over which blotting paper is stretched. He then pours the liquid metal into the funnel, and so fills up the mould, the stone covered with the blotting paper forming one side of the funnel and the mould, and preventing the metal from running away. The metal cools sufficiently to set at once, and the maker removes the mould from the stone, takes off the article which he has cast with a knife, and the process is complete. The blotting paper, strange to say, will sometimes last for a whole day. If, however, the metal is not quite right in composition, &c., it will burn in a few minutes. These articles require to be painted before they are ready for the market, and this part of the business is done by children, with brilliantly-coloured naphtha lacquer, which dries almost as fast as it is put on. The material employed to produce the green colour, is of a highly poisonous nature.

In an establishment, such as that of Mr. Bull's, the stock of moulds for this last class of toys forms an interesting collection. They are all made in gun metal, and, owing to their being in one piece, the wear and tear is almost inappreciable. Those used in the manufacture of the two other classes of toys show *signs* of damage in a few years, owing to the frequent putting of the parts together, and the consequent blows which the corners are continually receiving. The one-piece moulds, however, do not experience this rough usage at all, and consequently Mr. Bull has a considerable stock of them in perfect working order, which have been made at different times during the last seventy years. Some of these are very interesting. There are figures of Napoleon, Wellington, and other celebrated characters of the early part of the century; the first locomotive on its journey from Liverpool to Manchester; the steam locomotive for ordinary roads, which at one time went over London Bridge; celebrated singers and actors, particularly those of the comic class, such as Billy Walters, Black Sal, &c. In short, this collection forms a sort of historical series, for when new dies, which are constantly being required, are made, the most popular character or the last-known invention is of course immortalized.

The number of toys made thus is almost fabulous, though the demand for the different descriptions varies considerably. The principal call is for tea sets, as opposed to coffee and dinner sets. Nearly thirty times more of the first named are made than of either of the other two. At Mr. Bull's works a ton of metal is consumed each month, and some fourteen gross of tea sets and half a gross each of dinner and coffee sets are made on an average every week. The gross consists of twelve dozen, and each set contains on an average twenty-three pieces, so that this represents no fewer than fifty thousand separate articles turned out each week, or more than two-and-a-half millions in the course of the year. Besides these, there are the third class of pewter toys, made as above described in the one-piece mould. They are produced almost entirely for Christmas trees, and the manufacture of them is carried on for four months, extending from September to December. During that time no fewer than a hundred gross a week of the completed toys are turned out. Several consist of two or even three pieces, so that I may say, that at least twenty thousand pieces a week, in addition to those above mentioned, are cast during the four months at this one manufactory alone. Figures such as these give some idea of the extent of the trade, even in such very insignificant articles.

WOODEN TOYS.

The small and cheap wooden toys, which we see in all the humblest description of toy shops, are made in London in very large quantities. Among these I may mention pegtops, little carts, painted in the most brilliant colours, and with the most peculiar shaped horses and other animals attached to them; skipping-rope handles, penny rattles, hobby horses, and such like. Not a few are produced in the East end of London, and give occupation to many men and their families. The lathe comes into use in the production of these articles to a very great extent, and although the retail prices for goods of this class are so insignificant for each article, never being above a penny, and a great number not being more than a half-*penny*, yet they are as a rule almost wholly produced by the hand-labour of persons living in the most crowded parts of our large cities. The most important tools for this manufacture are the chisel and the lathe, which is worked with the foot, the gluepot being a necessary adjunct. The timber used consists largely of scraps, which are bought from the great builders' and contractors' yards, though not a little new material has to be cut up from the solid beam.

The establishment of the toy maker generally consists of a man and his family, though sometimes an extra hand is to be seen aiding in the more important part of the work, such as the turning; but as a rule this is done by the father alone, perhaps assisted by the eldest son. The wife and the children each has his or her particular share in the completion of the articles, such as the glueing of them together, the pasting on of the labels, the painting, the doing of them up for the wholesale houses, or, in not a few cases, the disposing of them to the public.

Some of the more expensive wooden toys, such as the beautiful horses and carts which are sold at establishments like Mr. Cremer's, and which are good models of the real things, are made in a somewhat similar way by families, but as a rule only to order. They of course command a high price, as each part has to be carefully constructed; and it is customary for large dealers to have a number of persons exclusively engaged on these goods, and to contract to take all which they make at a certain price.

PATENTED TOYS.

Toys, like articles in every other branch of industry, have frequently been patented. Many of these patented inventions have been useless or commercially valueless, but in not a few cases patents have been taken out for arrangements and contrivances, which have shown that a large amount of ingenuity has been displayed on their manufacture. Toys, coupled with games and exercises, have the distinction of having had a separate volume set apart for them in the 'Abridgment of Specifications' printed by the Commissioners of Patents.

The earliest patented invention in toys partakes of the mixed character of a toy and an exercise. It is dated 1672, and was taken out by one John Wells, and is described as follows:

"A certaine Engine which wil be of very greate vse and benefitt to the publique in teaching to performe by artificiall horses the vsuall exercizes of a compleate horseman, generally taught in academys (vizt.) the running at the ring, throwing of the lannce, shooting of the pistoll, and takeing vpp of the head, and that att such easy and cheape rates as may encourage many to learne the same whoe are otherwise, by the greatnesse of the expence, prevented from acquireing the said exercizes."

The next patent, taken out in the following year, is of a somewhat similar description, and then there does not seem to have been any invention patented, which can be regarded as a toy, for more than a *hundred* years. In 1788 a man named Holman took out a patent for a "machine for making marbles for children from various sorts of marble and other substances;" whether this invention accomplished the object of the inventor, it is impossible to say.

The next invention to which I refer is a somewhat quaint one. It was patented in 1810 by a W. Whitmore, and is called "the magnet toy, to facilitate the teaching of children to spell, read, and cypher, in any tongue, with ease to the teacher, pleasure to the learner, and proportionate expedition." Such an invention, I need hardly say, would be most acceptable at the present day, but I fear the further description will dissipate any hope of this toy fulfilling its lofty aspiration. The specification goes on to state: "This toy consists of a box (containing mechanism) having depicted on its upper surface either the letters of the alphabet, numerals, types, &c., according to the views of the teacher, arranged in a semicircular form, somewhat like the plate of a dial; an index revolving about the centre of the dial, carries a horse or other captivating, whimsical, or attractive device." This remarkable animal, it appears, by means of a magnet, or the mysterious mechanism in the box, is made "to take up any loose duplicate letter, a sign lying on the dial, to nod his head and otherwise amuse and instruct the children at the will of the teacher." We certainly cannot be surprised that both this toy and the animal, in spite of their being patented, became extinct creatures many years ago.

The next toy patent taken out was in 1817, by Sir David Brewster, and was for a plaything which has become familiar in every nursery, namely, the kaleidoscope. In the specification, the principle of its construction is very carefully explained. It states that "the successive reflections between the polished surfaces enable an eye placed at the aperture to perceive a circle of light divided into sectors; any object placed before the outer end of the tube appears repeated in every sector, and every image of the object will coalesce into a form mathematically symmetrical, and highly pleasing to the eye." At the end of the specification it is stated, that the kaleidoscope seems to realize the idea of an ocular harpsichord.

After this invention, nothing of any very great interest was patented until quite recently, that is, until the passing of the Patent Law Amendment Act, in 1852. Since that time the inventions have been numerous, and I do not, therefore, propose to go through them, but merely to glance at a few which are specially interesting, and which bear particularly on my subject.

A large number of these seem to have had for their object the securing of some particular process for making dolls or animals either dance or go through some sort of evolutions. Toys which are made "to do something" are always popular with children, and hence it has been the effort of the maker to produce articles of such a description so as, more or less, to carry out this object. To show the simplicity of some of these inventions which it has been thought worth while to patent, I may mention one, described as "a *mechanical* wooden horse." This consisted of a wooden horse which would gallop directly the carriage to which it was attached was set in motion. "To produce this, the axle or shaft of the hind wheels is cranked and set fast in the said wheels, the hind feet of the horse are fixed to this crank shaft, and consequently follow the rotation of the wheels." I think that there are traces of this invention, if such it can be called, in many of the carts and other articles to be obtained in almost every toy shop.

Several patents have been taken out for materials, to be used in the manufacture of different descriptions of toys. Thus a particular potato paste has been patented. The specification explains that the "potatoes are to be cooked as if intended for the table, bruised, and mixed with some pulverized article, such as fine sawdust, turf, or the waste bark from a tan-yard ground very fine, or any other fine powder, which can be had at small cost, the whole being worked into a fine paste by rolling and beating. The composition is then fit for use, and may be cast by the aid of moulds commonly used for such purposes. Compounds of indiarubber and guttapercha of every description have, as may be imagined, been protected by patents, and also pastes made of ground leather, as well as glue and other substances.

Two patents have been taken out by the same person for improvements in apparatus "for blowing bubbles from soapsuds or other liquids, to amuse children, and for other purposes." Such a fact as this shows how persons are employed for long periods, perhaps even years, in working out some trifling matter, such as that of a bubble-blowing apparatus, which may be bought for a penny at any market toy-stall.

The inventions in dolls, except as regards their locomotive powers to which I have previously referred, have been but few, and these for the most part relate to the materials employed in their construction. A contrivance for rocking dolls' cradles has been claimed as an invention, and patented, as well as several descriptions of go carriages, or walking apparatus for infants.

Among the chemical toys, I may mention Pharaoh's serpents, improvements in which, as regards the prevention of the fumes or other matters, have been patented by several persons. In principle these toys are all similar, and the amusement which they afford depends on the curiously grotesque and contorted elongations, which may be made to follow the combustion of certain chemical substances. Many improvements in toy guns, pistols, and cannons, have been secured by patents. These have been and always will be very popular playthings, and their character is such as to give considerable scope to invention: hence we find that patent triggers, patent air-pistols, patent toy fusees, lockets and such-like articles, are to be met with in great numbers. Kites are highly scientific toys, besides being very popular, and have in consequence received considerable attention. Several inventions for various modes of folding them up, have been patented. I may also mention rocking horses, battledores and shuttlecocks, swings, tops of various kinds, and in fact improvements in almost every description of toy which has at one time or another received the special attention of some particular maker, and whose improvements have been secured by patent.

From what I have stated, it will be obvious that the manufacture of toys has long ceased to be carried on exclusively on a small scale and by such men as Caleb the toy maker, who is so graphically described by Dickens in the 'Cricket on the Hearth,' but that a considerable amount of intelligence, capital, and skill have been brought to bear on this industry. The character of the articles patented during the past few years, as well as their number, testify to the truth of this statement.

The statistics of the toy trade are very difficult to arrive at, owing to the custom which prevails of so many people making goods at their own homes and not in factories. In London the approximate number of regular dealers and makers is about as follows: There are ten importers of toys, eleven rocking-horse manufacturers, ten wholesale dealers, and 151 retail dealers. These last do not include the infinite number of small retailers, who, in addition to the sale of toys, are engaged in some other occupation, particularly the vending of newspapers and tobacco. No fewer than fifty-one persons are recognized "toy manufacturers" in the sense in which I have alluded to them in various parts of this article, and although I cannot attempt to give the exact number who are at the present moment earning a livelihood in some way or other by the production of children's toys, there can be no doubt but that a considerable proportion of a certain class of the population is thus occupied.

As far as I am aware, no attempt has hitherto been made to bring this subject before the public, it probably having thought too insignificant and unimportant. This is not the place to consider the proper uses to which toys may be applied, and it is not my intention to enter into the educational aspect of the question, by showing how these trifles may be made to subserve purposes of instruction without such instruction being made tiresome to children. I may, however, safely assert, that objects which we all require to use during a great part of our early life, and which have such an immense influence on us, and added so much to the happiness of our earliest years, cannot in any way be considered as unimportant.

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